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Journal of the Society of Arts.

FRIDAY, AUGUST 6, 1869.

Announcements by the Council.

EXAMINATIONS, 1870.

The Council have this year decided to remove from the Programme those subjects in which the Science and Art Department holds examinations, which, it appears, are now largely taken advantage of by the same class of persons (and very often by the same individuals) as those who sit at the Society's examinations. The following subjects will therefore not appear in the programme for 1870 :—

Algebra.	Light and Heat.
Geometry.	Chemistry.
Trigonometry.	Mining and Metallurgy.
Conic Sections.	Botany.
Navigation, &c.	Animal Physiology.
Principles of Mechanics.	Free-hand Drawing.
Practical Mechanics.	Practical Geometry.
Magnetism, Electricity, &c.	Mechanical Drawing.

Owing to a prize of £5 having been kindly offered by Earl Fortescue, President of the British Branch of the International Decimal Association, the subject of the Metrical System will be retained.

The programme is now in preparation, and will include some further modifications in the system, but the above, being by far the most important, are announced at the earliest opportunity.

IMPROVED CABS.

The Council of the Society of Arts offer the following medals for improved hackney carriages specially suited to the metropolis :—

The Society's Gold Medal for the best and most convenient open hackney carriage for two persons.

The Society's Silver Medal for the second-best ditto.

The Society's Gold Medal for the best and most convenient closed hackney carriage for two persons.

The Society's Silver Medal for the second-best ditto.

The Society's Gold Medal for the best and most convenient hackney carriage for four persons, either open or closed, or both.

The Society's Silver Medal for the second-best ditto.

Lightness of construction, combined with adequate strength and durability, will be especially considered in making the awards.

The awards will be made after actual trials of the carriages extending over a certain period.

Communications describing the carriages must be sent to the Secretary of the Society of Arts before the 1st January, 1870, the carriages to be sent to a place hereafter to be appointed.

The Council also offer the Society's Silver

Medal for the best instrument, to be affixed to a cab or other hackney carriage, for indicating the fare as between the passenger and the driver, whether by registering the distance travelled or otherwise, and which instrument shall also indicate, for the convenience of the cab-owner and of the driver, the total distance travelled during the day and the total amount earned. The instruments competing, with full descriptions of their construction, to be sent to the Society's House before the 1st January, 1870.

Competitors may, at their option, sign their communications, or may forward with them sealed letters containing the name and address of the writer.

The Council reserve to themselves the right of withholding all or any of the medals, in case none of the carriages or instruments possess, in their opinion, sufficient merit.

SUBSCRIPTIONS.

The Midsummer subscriptions are due, and should be forwarded by cheque or Post-office order, crossed "Coutts and Co.," and made payable to Mr. Samuel Thomas Davenport, Financial Officer.

Proceedings of the Society.

NATIONAL ELEMENTARY TRAINING AND EDUCATION.

The first display of the physical and industrial training on the half-time system at the North District Surrey School, on the 3rd July, had given, to the members of the Council who attended it, deep impressions of the importance of the system, far deeper than any they had before entertained, or could have conceived, of the effects of the bodily training, without having witnessed them. The Council, therefore, begged to have a repetition of the exhibition, for the sake of members of the Society who are in Parliament, as well as of others who are specially interested in the subject of national elementary education, who had been unable to be present on the first occasion. A second display was therefore obtained on Saturday, the 24th July. Amongst those present were—The Hon. Dudley Fortescue, M.P., Mr. Bernhard Samuelson, M.P., Professor Huxley, F.R.S., Professor Masson, Mr. Henry Cole, C.B., Mr. J. Scott Russell, F.R.S., Mr. Edwin Chadwick, C.B., Mr. Hyde Clarke, Mr. Seymour Teulon, the Rev. Mr. Raven, Mons. Arles-Dufour, and Major-General Wilford, R.A., who were received by Mr. J. C. Bennett, chairman, and Messrs. J. Kent, L. Adams, J. Carter, and the Rev. Mr. Congreve, members of the Board of Managers of the school.

All doubt of the benefit of the examinations, and of their repetition in the interest of the administration, was decisively dissipated by the results of the visits in the vindication of the advantages of the treatment of orphans and destitute children in buildings, apart from the adult paupers—in the great gain in efficiency, as well as in the economy of the school-teaching power, by a division of educational labour in the school—in the great gain of bodily aptitudes for labour by the military drill and gymnastics, as well as by the industrial training; and by the evidence of the general gain in the economy of results. Under the former and too prevalent present practice, only one child out of every three turn out indifferently well at present, whilst here the absolute moral and industrial failures scarcely exceed one or two in fifty. In the minds of those present who examined the training in this institution, with a due consideration of the inferior material operated upon, there could not be the slightest doubt of its superiority of economy in result, even with some increase of present charges over any plan of treatment in cottages, wheresoever uncrowded and fitting cottages might be found. It was regretted that the facts displayed in these visits should be so long unknown to members of the legislature, and to those specially interested in the subject of national elementary education. In answer to congratulations of the members of the Council on the general success of the administration, Mr. J. C. Bennett, stated that he had always been in favour of such visits, and he should be glad if visitors would come frequently and unexpectedly; and he recognised fully the fact that they stimulate the minds and the attention of the pupils as well as all the officers. He expressed the obligations of himself and the other members of the Board of Managers to the Council of the Society of Arts for the notice given to their labours by the distinguished visitors who had examined them. Professor Huxley, after pointing out to the children briefly the value in their after working-life of the kind forethought of the managers, thanked the latter for the opportunity of witnessing this successful experiment in industrial and general education. One valuable feature was that it began at the bottom, whereas most begin at the top, hoping that the streams of knowledge would percolate down below; but there might be said to be a stratum of clay on a layer of sand, and he had been one of those who had vainly been working at the top for many years. The right course is to work on the masses at bottom—let knowledge flow upwards. Few, he said, can know the difficulties of the managers of these schools, from official and non-official ignorance. Non-official ignorance is ever ready to check the guardians in each liberal effort, and official ignorance is equally obstructive. The remedy for these evils is a better knowledge of what is being done by the guardians in such institutions.

On the general question of the improvement of national elementary education, these visits served as an important demonstration of the practicability of teaching the "three R's" in a highly improved manner, up to decimal fractions inclusive, together with music, elementary drawing, and a bodily training and drill, superior to anything afterwards attainable before the eleventh year, when the wage-classes must have the benefit of their children's services, and of gaining between two and three years for technical instruction of the children of those classes who can afford to allow them to remain up to the thirteenth or the fourteenth year. The examination papers of the pupil teachers, and also the examination of the elder classes in the school in geometry, and other points for technical training, were demonstrative on these points.

Those who are specially interested in the promotion of technical education are recommended to visit this school, and also the Central District School of London at Hanwell, and examine the gains generally practicable for technical education by an improved organisation of the means of elementary instruction. The Council are led to believe that the City of London Middle Class School, originated by the Rev. W. Rogers, a mem-

ber of the Council, and recently organised under the Rev. Mr. Jowitt, will furnish important illustrations of the superior technical instruction that may be extensively imparted within the two or three years of time that may be gained by a better organisation of primary elementary instruction.

Major-Gen. Wilford, R.A., late Governor of the Royal Military Academy at Woolwich, was good enough to review the military exercises* of the juvenile forces, and he pronounced the drills to be excellent. He considered the drill to be really as good, even at this stage, as any that would really be required, and that it would not be forgotten by the boys. It was better than the drill in France. He thought we over-drilled our men for practical purposes. He complimented the managers of the institution that, whilst they had imparted to the boys qualities of great value for civil life, they had also imparted qualities of high importance, if needs were, for the military service of the country.

The Council considered it of importance that these bodily attainments, practicable in the juvenile stages under a national system of elementary education, should be more extensively displayed and publicly witnessed. They, therefore, proposed that the managers of the chief schools in the metropolis, where the military drill has been introduced, should be invited to send their boys to be reviewed at a grand school review at the Crystal Palace, the directors of which agreed to pay the expenses of their transit and to give them refreshments. In the absence of the President of the Society, His Royal Highness Prince Arthur, with the gracious approbation of Her Majesty, consented to direct the review, and to distribute any assigned prizes or proper commendation for excellence in drill. Cordial approbation had been expressed of the proposal from the War Office, and of an invitation that the boys of the Royal Military Asylum, at Chelsea, should take part on the occasion; and similar approbation was anticipated from the naval authorities for the participation of the boys of the Royal Naval School at Greenwich in the exercises. The managers of eight large district schools and institutions immediately and cordially responded to the invitation given by the Council. On the whole they were prepared to expect that an immediate array of between two and three thousand boys would have been presented for review before his Royal Highness. But some obstacles prevented the plan being realised before the time fixed for the departure of his Royal Highness for Canada, and the Council were compelled to postpone it. The Council regret the disappointment occasioned to the great body of children, whose expectations were excited, and to the managers of the educational institutions, the drill masters and the school teachers, but the Council trust that the disappointment will be compensated by a more complete and larger organisation for another and early occasion, for which they venture to recommend the schools to prepare themselves.

It may be proper to observe that, whilst there may be large differences of opinion on the question of a national military organisation, the Council have received the expression of almost unanimous opinion, amongst the military and naval members of the Society and other military authorities, in favour of the general introduction of military drill and naval exercises as part of a system of national elementary education. But without derogating from the importance of that object, as one of national economy, the Council would call the attention of the Institutions in Union, and of educationists, as well as of their members, to this subject, as one strictly in unison with their civil objects, as a means of improving technical education and the advance of the productive

* On the first visit, the boys of the Lambeth School were drilled after those of the North Surrey School had been exercised in review, when the drill of the Lambeth boys was pronounced to be superior. On this occasion it was noticed, as one advantage of these repeated visits and comparative inspections, that the North Surrey Institution had been stimulated to improve its drill, and had succeeded, especially in the most difficult of marches—the march in slow time.

power of the country. In justification of this distinct view, the Council draw attention to the following practical evidence, given to the Newcastle Commission on Popular Education, by some eminent members of the Society, and others of the largest practical experience as leaders in arts and manufactures :—

Joseph Whitworth, Esq., F.R.S.

What number of working men, mechanics or labourers, may you have in your employment?—From 500 to 800.

Are they adults?—Chiefly adults.

Have you had experience of any inconvenience which the application of a naval or military drill, in the education of children, would serve to prevent in large establishments?—Yes, in large establishments like ours, it is frequently necessary for men to act in concert. We find great loss of power by men not acting in concert. Serious accidents frequently happen from this cause, as well as much general disorder.

What do you believe would be the value given to a youth by a previous naval or military drill, or both, in his school education?—I would consider a youth of double the value who had a previous training in a drill which gave him habits of order and cleanliness. I do not mean his own personal cleanliness, but keeping everything he has to do with in a high state of cleanliness. A youth who has had a training of the nature of a drill has a pleasure in attending to commands, whilst another, not so trained, is dull, and dilatory, and inefficient. The drill, besides correcting defects, brings out special bodily qualifications. Thus, one youth, who is remarkably strong in the upper extremities, will be found to be specially adapted to one sort of work, whilst another, who is more powerful in the lower extremities, will be the best fitted for another. But the drill would be of great use, as giving qualifications for all occupations.

Have you had any experience of the effects of naval and military discipline in improving the qualifications of workmen?—We always prefer a man who has been a sailor to take charge of the men employed in rendering assistance to others, in lifting and removing objects from place to place; he is more apt in the use of blocks and tackle, and better drills the men to act in concert.

William Fairbairn, Esq., F.R.S., of the firm of Fairbairn and Sons, Mechanical Engineers, Manchester.

What number of mechanics and labourers do you employ?—Nearly 1,000.

What is your experience and observation as to the effects observable of the military or the naval drill on the habits and efficiency of labourers as workers?—We find that men who have been soldiers or sailors obey orders with greater precision than others, that they are more punctual, and more tractable, and require less superintendence or attention than the others. We do not meet with men who have been drilled amongst the skilled mechanics, but we find the drilled men amongst the common labourers, as compared with whom they are very superior. We have had for many years, as foreman of our labourers, a man who had been trained as a sailor, who had in fact been a sailor, and we find him extremely handy. His knowledge of the use of tackle in raising heavy weights is extremely convenient, as well as his habits of command over the men; moreover, there is a much less risk of accidents from men who are so trained, they go about their work with more knowledge and skill than the undrilled.

What, from such experience, is your view of the expediency of the naval and military drill as a part of school exercises and gymnastics, and its effects on the efficiency and value of the scholars as workers in after-life?—In my view, a greater benefit could not be conferred on the population of the country than to provide for them a military and a naval drill, interspersing with their school instruction systematic gymnastics. It would be in every way profitable to them and salutary. Their active bodily training cannot begin too early, and

from my own experience as a boy, when it was a favourite game to “play at soldiers,” it would be as agreeable as it would be useful to youth in the duties of ordinary civil life.

You have mentioned the avoidance of accidents as one benefit experienced from the employment of drilled men. Are you aware that the total number of deaths registered during the last year from accidents from contusions, stated in the official reports as arising chiefly in the employment of the agency of steam, was above 5,800 in England and Wales alone?—I was not aware of such an extent of loss over the whole kingdom, but I was aware that in the Manchester district the average loss of life from boiler explosions alone is, as near as I can recollect, about 120.

Have you not, in writings or addresses, represented the necessity of having a higher order of education and intelligence for the management of the agency of steam?—I have endeavoured repeatedly to show the absolute necessity of a higher scale of intelligence, such as an improved training and education might impart, not only to the working population having charge of the great new agency of steam and steam machinery, but to those having superior direction of that agency. The great mass of accidents arise from ignorance of one sort or other, or neglect. The ignorance is displayed in instruction, as well as in management.

Robert Rawlinson, Esq. C.B., Civil Engineer, late one of the Sanitary Commissioners to the Army in the Crimea.

Have you not had an extended practical experience in public works and with working men?—Yes.

Would special naval and military drilling and gymnastic training at school give useful aptitudes for labour generally?—In my opinion, based on experience and observation, I think school drilling and training would prove of the utmost consequence to the boys in after-life. I may give a few instances. In all engineering and building trades, men are frequently required to use their strength in concert, lifting, carrying, and drawing. Men, to use their joint strength, not only effectively but safely, must have confidence in each other. Two trained men will lift and carry more, easily and safely, than four untrained men. I have frequently seen trained men weed out untrained men, where heavy lifting has been required, because they dare not risk the danger arising from unskilled strength; and few have performed with more safety work which would have been lighter and easier if all had been equally skilled. Men frequently reject the assistance of unskilled men, as there is absolute danger in having them near. Frequently accidents arise from using men unskilled in lifting, in hoisting, and at capstan work. Men who have been sailors make by far the best labourers, and coasting sailors the best of all. In Liverpool, Welsh sailors are preferred for all purposes of scaffolding; that is for making tall scaffoldings for buildings. Men who have been marines are next best, and then men who have been soldiers. Boys should not only learn to march, but to lift, carry, and pull in concert. There are many necessary feats of strength in all trades which are more matters of knack and tact than of brute strength. Brute strength frequently fails to do that which comparative weakness can accomplish easily with skill and confident concert. There is no regular system of training in concert to use human strength in the best manner in any trade, so far as I know; acting in concert is matter of necessity, and practice gives facility and confidence. Drill and training would probably double the effective human power of any establishment, especially if numbers are instructed in joint feats of strength. That which is taught to youth is never forgotten in after-life.

Mr. George Sykes, Machinist and Engineer.

Was foreman at the manufactory of Sharp, Stewart, and Co., Manchester, formerly Sharp Brothers, engine makers. He had nearly 300 men under his direction.

Amongst the men there were some who had been soldiers in the line; they were distinguished as most steady men, as keeping everything tidy and orderly, and being prompt and active. "I am quite satisfied that they were worth more money than others in the shop. If I were the employer, I would give 2s. or 3s. a-week more than to others to whom £1 a-week is paid. I am satisfied, from observation, that the habits begot by the drill would improve workmen to at least that extent. There is much loss of labour by the awkwardness of labourers not pulling together, not lifting together, and not being unanimous. Many accidents are occasioned by awkwardness; three out of four that I have seen have been from awkwardness and stupidity, which was not displayed by the soldiers. As a foreman, I should not have had half the trouble if all had been drilled and had had the same habits of obedience, and would have 'been told' as the soldiers."

From your experience of the effects of drill, if you had a son, and there were an opportunity of getting him into a school where pupils received a good drill, would you be willing to pay extra for it, to improve his qualification as a working man?—Yes; if I were paying 1s. a-week, which is what is commonly paid for a good private day school, I should be willing to pay 1s. extra for his teaching in a school where he would be drilled and have a good bodily training and be well set up. I am sure it would be worth while.

The Count Gasparin.

The Count Gasparin, an accomplished statesman of France, the writer of the most able work on agriculture in Europe, in treating of the inconvenience to which agriculturists, small farmers of France, are subject, adverts to the liability of the family stock of labour, that of their sons, being disturbed by the conscription, or as their being taxed to procure substitutes for their sons when drawn to serve in the army. He says, that if the labour of the son can be supplied by a little more activity on the part of the other labouring members of the family, if the labour of that son be not absolutely necessary,—but above all if it be necessary to go into debt to raise the price of the substitute,—the father of the family cannot be too strongly advised not to prevent his son joining the army. "We have," says the count, "experienced such good effects from the adoption of this advice, that we cannot too often repeat it here. The families who have followed it have saved their money, and they have seen the son return more vigorous, more intelligent, more respectful, more capable, having lost his rusticity (*sauvagerie de la campagne*) and become able to deal with men with more ease and consideration. Our discharged soldiers are, in general, the best subjects of their villages; it is amongst them that we find our best foremen and our best stewards, whilst their brothers who have remained at home are only common loutish labourers."

Sir Francis B. Head, Bart.

Of military evidence, bearing on the use of the drill for civil service, that of Sir Francis Head, Bart., R.E., may be cited:—

No animal, whether on four legs or on two, however he may enjoy life, can be of any use in the workshop of man until he has been sufficiently divested of that portion of his natural inheritance commonly called "a will of his own."

What's the use of a cow, if she won't allow either man or maid to milk her? What's the use of a horse, if he won't put his head into a collar, or suffer a saddle to be placed on his back?

The dull-sounding but magic little words of command, "Eyes right!" "Eyes left!" "Eyes front!" "Right turn!" "Left turn!" "Right about turn!" "Left about turn!" "Quick march!" "Halt!" "Stand at ease!" "Attention!" &c., instil into the minds of a lot of little boys the elements, not of war, but of peace. Instead of

making them ferocious, these words (to use Mr. Rarey's expression) "gentle" them, until, by learning to be subservient, not to their own, but to the wills of others, they become fit, in every possible department, to serve their country.

On entering the Foreign-office, Home-office, the church, the counting-house, the manufactory, or the farm, in which they desire to labour, their habit of obedience would prove so beneficial to their employers as well as to themselves that I feel confident, if a system of drill be once adopted in our public and private schools, a tall, undrilled young man, like a raw, unbroken horse, would, by the generality of dealers, be considered as "unserviceable."

INFIRMARY.

As much interest was excited among the visitors to the infirmary of the Institution, the following particulars are given:—

In an establishment like the Anerley School, where nearly 1,000 children are assembled, equalling in number the children in a large town, it is a matter of certainty that some disease must exist. To prevent, as far as possible, the propagation of disease from one to another, early separation of the sick from the healthy is deemed of the utmost importance; and in order to treat those who are sick in the best manner possible, an infirmary is provided, to which every case, however apparently trivial, is always sent, and it is usually found that from five to ten per cent. of the children are affected with some ailment or another, but generally of no important kind.

Until within the last few months, no child was received into the schools from the union workhouses if suffering from any disease, unless the disease was of such a nature as to render the return of the sick child dangerous; but now, on the contrary, sick children are sent as well as healthy ones; therefore the infirmary at the North Surrey District Schools is, to some extent, the children's infirmary for the North Surrey school district. As far as the children in the schools are concerned, this is not a good practice, as disease is introduced from external sources, which has, in some instances, been communicated and spread to other children of the establishment.

The great and injurious source of illness is from children who are always going out and into the schools, and from others introduced in the way before-mentioned. The infirmary is calculated to receive 170 patients, each having a separate bed, with 750 feet of cubic space to each bed. The height of the wards does not exceed twelve feet, in order that, in calculating the cubic air space, a sufficient area may be provided to prevent the beds being too closely placed together, and to render the warming of the wards more easy. The infirmary faces to the south-east. There are eight wards, besides two small wards for special cases. In every ward a small space is parted off for the nurse or servant to sleep in at night, where everything that goes on in the ward may be seen and heard. The wards are ventilated by sash windows on each side, by Sheringham ventilators, and by an air-shaft over the gas-burners, and by this means the wards are kept perfectly sweet and properly aired. To each ward latrines are provided, with a bath-room with hot and cold water, a sink, and two water-closets, quite separated from the wards by a ventilated passage. The pipes from the sinks and baths have their outlet over a trapped draw outside the building, with which they have no direct communication, so that no sewer gas can enter from the drains. A large day-room is provided on both the male and female side, for convalescents. All the cooking and washing, &c., are done in buildings adjacent to the infirmary yards, so as to be entirely separated from the main buildings. The infirmary was built from plans drawn by the superintendent and medical officer, which were carried out under the superintendence of the architect, Mr. Birney, of Croydon.

CANTOR LECTURES.

ON APPLIED MECHANICS.

BY JOHN ANDERSON, ESQ., C.E.

LECTURE II.—DELIVERED MONDAY, APRIL 19TH.

Applied Mechanics in relation to Natural Properties of Materials.

The branch of this subject which relates to the construction of machinery resolves itself into several distinct parts. First, there is the object which is to be accomplished by the machine; secondly, the natural or mathematical principle to be employed in accomplishing the object; and thirdly, the mechanical arrangement which has to be contrived and made in order to carry out the principle. Then, after the machine is constructed, there is, fourthly, the power of nature to be employed in giving motion to the machine, and then after that comes the combination of solitary machines into systems for the development of manufacturing operations, and embracing their application to the various purposes of life in the working world generally, nearly all of which depend on natural principles much more than on men or man's mechanism. It will thus be seen that the machinery subject is made up of two grand divisions—first matter, then motion. Both this lecture and the next will have reference chiefly to the natural properties of materials, to the natural laws of the processes, and to some of the means employed in giving them definite forms for their intended purpose. The fourth lecture will refer to matter in motion.

To the young engineer who has just left school for the workshop, there to learn the duties of his future occupation, the various materials with which he comes into contact have a different appearance to the reality. Most of them have the appearance of being solid continuous masses, and rigid in their nature. After a little experience he begins to find that such is not the case; that everything is more or less porous, all of them differing in density; that none are positively rigid; that all are more or less elastic; that many of the substances usually called solid have a property resembling the flowing or unstable property of fluids; that they can be variously modified in regard to their toughness, brittleness, tenacity, or rigidity; and that, in their relation to heat, each and all are similarly yet differently affected, according to their peculiar natures or characteristics. With such properties all are more or less familiar, but there are other physical conditions that are too little studied in the workshop.

The constitution and mutual connection of the primary or indivisible atoms composing the molecules of any substance, such as iron or copper, is a subject not very clearly understood even by the learned, but philosophers nearly all agree that the ultimate indivisible and indestructible atoms consist of exceedingly minute particles, which are invisible to the most powerful microscope, and are indeed very much smaller than the mind can realise; but it is supposed that these primary atoms are not in actual contact with each other, but that the entire structure is what may be termed cellular, pervaded by a portion of infinite space around each atom, and by space only, the distance of separation being far too small for the gross matter of gas or atmospheric air to penetrate, space only filling up and forming a continuous envelope or wrapping of empty space, penetrating as a sort of network around each individual atom, and that all are held together by the universal law of cohesive attraction, and kept apart by the mysterious agency of heat, or by some other similar influence still more obscure.

The investigation of the physical laws, so far as they relate to the primary atoms, lies far beyond the verge of applied mechanics; indeed, it is a subject that almost reaches to the spiritual, but the aggregation of these atoms into the secondary or molecular condition inti-

mately affects all our operations. The individual molecules of matter, as thus composed of a number of primary atoms, are likewise so exceedingly small as to be beyond the imagination. Still, they have mechanical properties; they separate from each other and mix with other molecules, and they permit heat to push them asunder into a wider space. This also is an obscure subject at the present time, and one beset with many practical difficulties, because our knowledge is not definite enough; the natural laws that govern the molecular adhesion, and the order of their arrangement with other molecules, are not yet thoroughly understood, and there are at this moment many practical operations depending on such mixings, coatings, or combinations that still wait for a clear solution, and which will not be solved satisfactorily until the natural law that regulates molecules is ascertained more fully; still the knowledge is advancing, and every succeeding year reveals another and another of nature's secrets. A due appreciation, however, of what is already known in regard to this molecular structure or condition of materials, will greatly assist in preparing us to understand the possibility of such remarkable properties as malleability and ductility, in consequence of which the particles, or rather the molecules, can be spread out, gathered in, or even pushed about, or can even be drawn out from amongst each other. It also enables us to comprehend the nature of the various changes that take place in regard to their molecular adhesion or tenacity and compressibility, by the presence or infusion of other molecules, such as in the union of iron with a trace of silica, which, from its behaviour, would almost seem as if it formed a coating of invisible varnish around the particles; or the still more striking effect when the silica is eliminated, when we frequently see the superseding varnish of oxygen, or whatever physical condition it may assume, which from some obscure reason seems to produce brittleness when in the red-hot state. Equally important changes are produced by the presence of sulphur, phosphorus, manganese, carbon, or other substances. Equally wonderful are the changes wrought in regard to their varying conditions of elasticity and brittleness, hardness and softness, toughness, malleability or ductility, by what may often seem to be a small cause to produce such an extraordinary effect, more especially in regard to the change produced by different modes or rates of cooling, or by other analogous treatments, all of which phenomena we can daily witness and ponder over in the workshops of applied mechanics, even if we may not always be able to afford a ready and clear explanation.

We may consider materials under this secondary aggregation of a number of atoms into molecules which are probably held together by the force of attraction, but which are prevented from getting into actual contact, probably by the repelling influence of heat or some other agency, for although the presence of heat may not be perceptible to our senses, especially at low temperatures, still, by increasing the heat, we then find that it gradually overcomes the cohesion, and that the solid body at length becomes a liquid, such as in the case of ice becoming water; or the liquid metal, as in the case of lead; or by still further increasing the heat, its presence sometimes becomes visible, even with water when contained in a vessel strong enough to bear the pressure, and frequently with lead, even in an open vessel, or as we daily see in the case of cast-iron when it is melted by the foundler. In all these instances the molecules of the solid substances are pushed beyond the range of cohesive attraction which existed in the solid, and of which man learns to take advantage. He then devises arrangements for pouring the metal into moulds or otherwise, and by waiting until the heat has passed off, either by conduction or radiation, the law of molecular attraction again asserts its dominion over the solid, and the molecules are brought closer together into a more rigid state of relationship one with the other.

By still further increasing the heat, as in the case of water

when converted into steam or vapour, the invisible molecular particles of the water but now in the state of steam, are thereby separated into space, finally beyond the reach of each other. It is the same with the metals or other substances, provided that a sufficiently high temperature is employed. Even the metal iron is thus converted into vapour, and its molecules pass off into space, probably never to meet again.

Besides this minute molecular or secondary structure of materials, there is a still coarser order of structure, variously modified into a crystalline, cellular, or tubular arrangement, which may be seen with the microscope, and even with the eye. It is so coarse in some materials as to permit the air or even water to permeate the mass. In such materials we often find the molecules arranged in porous clusters, crystals, fibres, cells, or otherwise, according to the nature of the particular substance, each substance having its own peculiar characteristics, and all governed by special properties of their own, quite distinct from the general laws which govern all matter alike. In this branch of applied mechanics it is chiefly the coarser properties that have to be dealt with and considered. We may consider such substances in regard to the molecules of matter composing them, which are, in virtue of laws not yet well understood, thus found to arrange themselves into crystals that are apparently held together by the influence of cohesive attraction, and kept a certain distance of space apart by repulsion, from heat probably, and that these two forces are antagonistic and in constant operation, thus keeping every mass in a condition of restless activity, atoms amongst atoms, and molecules amongst molecules, and crystals amongst crystals, and when the repelling influence arising from the presence of heat is able to overcome the attractive force, then the force of cohesion is thereby diminished, and hence it is that the molecules of the metals, for example, are more easily moved about when at a high or red heat than when at a lower temperature, which the smith takes advantage of and not only do we find that the attraction is lessened, but that the distension of mass, arising from the repelling influence, is such as sensibly to enlarge the volume of the substance, so that the difference of dimension is measureable, and sometimes to such an extent as to be even perceptible to the eye.

The natural condition or property of matter, termed porosity, as exhibited by different kinds of common materials, may be looked upon as the opposite condition implied by the word density, hence both terms may be considered as co-relative, as the greater the density, so the mass is, of necessity, the less porous, and both terms may be applied to the same substance.

The whole of the materials used by the engineer, such as the woods and metals, are more or less porous, and, as already stated, sometimes even to the admission of such coarse substances as air and water.

With the porosity of woods, all are more or less familiar. Cork is almost a type, being so porous and compressible. Cork, when sunk a few hundred feet in water, will have its porous structure so filled up by the fluid pressure, as to render it incapable of floating for some time, until it has undergone a process of desiccation. Charcoal, also, is so porous as to admit of many times its own volume of gas to be condensed within it.

A good illustration of the extreme porosity of wood is afforded by the Boucherie system of preserving timber, by forcing a liquid through its pores from end to end. The tree or log is laid upon the ground, to obtain fluid pressure. A ring of vulcanised india-rubber is introduced, in order to form a close joint between the end of the tree at its outer margin and a circular or other shaped plate, or even thick board, which is held to the tree by means of screws. Into the centre of this board or plate a stop-cock is inserted, which is connected to a pipe leading upwards to a cistern containing the liquid, placed some sixty or seventy feet from the ground, the cistern containing either sulphate of copper, chloride of

zinc, or some other antiseptic solution. When the stop-cock is opened, the fluid pressure from the preserving solution in the cistern fills the space between the board and the tree, and so by fluid pressure causes the sap to flow out of the other end of the tree or log in a clear stream, and in large quantity, thus showing the great porosity of the wood in being able to hold such a volume. In the course of an hour or two the whole of the sap is expelled, and the antiseptic fluid makes its appearance at the other end. The solution is allowed to remain in the pores of the tree, thus leaving it thoroughly saturated throughout its entire length.

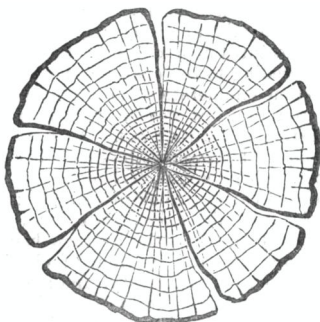
In the carrying out of this process, it is interesting to observe the difference between the respective periods of time that the solution requires to pass through a tree lengthways and through a thin board cut transversely from the same. For example, a tree ten feet long as compared with a board one inch thick, are both found to require about the same period for the liquid to pass; that is to say, it proceeds 120 times faster the one way than the other, arising from the conditions of structure. Advantage is taken of this peculiar porosity of wood, in the manufacture of the wooden pins or trenails which are sometimes used to fasten railway chairs upon the sleepers, and also for a variety of other purposes. The trenails are generally made of oak, which are first formed into round pieces one and a half inch in diameter, then, by means of mechanical pressure, they are forced into a metal die one inch in diameter, where they are allowed to remain for an entire day, at a temperature a little under that of boiling water. When the trenails are taken from the dies they are thus reduced two-thirds of their original diameter by the collapsing of the longitudinal tubular structure, but when they are driven into the sleeper they soon have the opportunity for the capillary laws to come into play by absorbing moisture, then they regain about three-fourths of their original diameter, thus taking a firmer hold of the sleeper, and at the same time their strength is increased in addition.

Notwithstanding the extent to which timber is used in the mechanical arts, it is singular that the natural law by which the contraction or shrinking of wood is governed is too much disregarded in practical operations. It is a subject which seems to have been entirely neglected by writers on the subject, for I am not aware of any book that explains the subject fully, and have only met with one individual (Mr. Wilson, of Patricroft,) who has thoroughly studied it as a philosophical question, and reduced it into the every-day unerring practice of his own works. The wretched state of the floors, doors, and shutters in many of the London houses too plainly give ample and complete evidence of our persistent disobedience of the law, more especially in this quarter, and the only hopeful consolation is that we do not go unpunished, as the penalty inflicted may in time lead to improvement.

An examination of the end section of any exogenous tree, such as the beech or oak, will show the general arrangement of its structure. It consists of a mass of longitudinal fibrous tubes arranged in irregular circles that are bound together by means of radical strings or shoots, which have been variously named; they are the "silver grains" of the carpenter, or the "medullary rays" of the botanist, and are in reality the same as end wood, and have to be considered as such, just as much so as the longitudinal woody fibre in order to understand its action. From this it will be seen that the lateral contraction or collapsing of the longitudinal porous or tubular part of the structure cannot take place without first crushing the medullary rays, hence the effect of the shrinking finds relief by splitting in another direction, namely, in radial lines from the centre, parallel with the medullary rays, thereby enabling the tree to maintain its full diameter, as shown in Fig. 1. If the entire mass of tubular fibre composing the tree were to contract bodily, then the medullary rays would of necessity have to be crushed in the radial direction to enable it to take place,

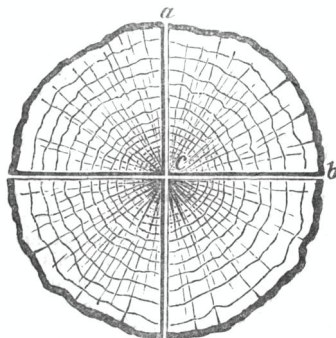
and the timber would thus be as much injured in proportion as would be the case in crushing the wood in the longitudinal direction. If such an oak or beech tree is

FIG. 1.



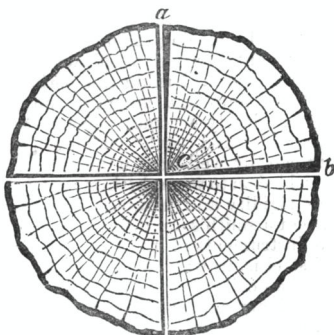
cut into four quarters, by passing the saw twice through the centre at right angles, before the contracting and splitting has commenced, the lines *a*, *c*, and *c*, *b*, in Fig. 2 would be of the same length, and at right angles to

FIG. 2.



each other, or, in the technical language of the workshop, they would be square, but, after being stored in a dry place, say for a year, it would then be seen that a great change had taken place both in the form and in some of the dimensions; the lines *c*, *a*, and *c*, *b*, would be the same length as before, but it would have contracted from *a* to *b* very considerably, and the two lines *c*, *a*, and *c*, *b*, would not be at right angles to each other by the portion here shown in black in Fig. 3. The medullary rays are thus

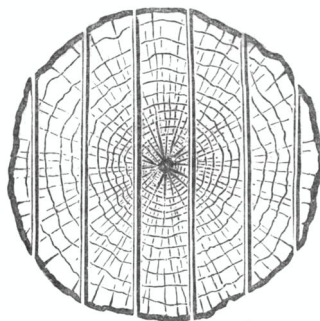
FIG. 3.



brought closer by the collapsing of the vertical fibre.

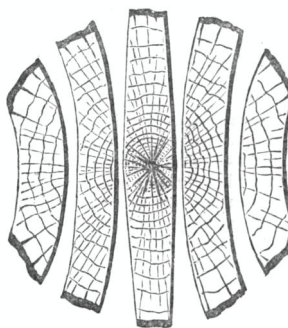
But, supposing that six parallel saw cuts are passed through the tree so as to form it into seven planks, as shewn in Fig. 4, let us see what would be the behaviour

FIG. 4.



of the several planks. Take the centre plank first. After due seasoning and contracting, it would then be found that the middle of the board would still retain the original thickness, from the resistance of the medullary rays, while it would be gradually reduced in thickness towards the edges for want of support, and the entire breadth of the plank would be the same as it was at first, for the foregoing reasons, and as shown in Fig. 5. Then,

FIG. 5.



taking the planks at each side of the centre, by the same law their change and behaviour would be quite different; they would still retain their original thickness at the centre, but would be a little reduced on each edge throughout, but the side next to the heart of the tree would be pulled round or partly cylindrical, while the outside would be the reverse, or hollow, and the plank would be considerably narrower throughout its entire length, more especially on the face of the hollow side, all due to the want of support. Selecting the next two planks, they would be found to have lost none of their thickness at the centre, and very little of their thickness at the edges, but very much of their breadth as planks, and would be curved round on the heart side and made hollow on the outside. Supposing some of these planks to be cut up into squares when in the green state, the shape that these squares would assume, after a period of seasoning, would entirely depend on the part of the tree to which they belonged, the greatest alteration would be parallel with the medullary rays. Thus, if the square was near the outside, the effect would be as shown in Fig. 6, namely, to contract in the direction from *a* to *b*, and after a year or two it would be thus, as seen in Fig. 7, the distance between *c* and *a* being nearly the same as they were before, but the other two are brought by the amount of their contraction

FIG. 6.

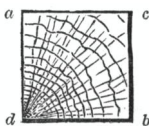
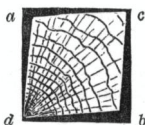


FIG. 7.



closer together. By understanding this natural law, it is comparatively easy to know the future behaviour of a board or plank by carefully examining the end wood in order to ascertain the part of the log from which it has been cut, as the angle of the ring growths and the medullary rays will show thus, as in Fig. 8. If a plank

FIG. 8.



has this appearance it will evidently show to have been cut from the outside, and for many years it will gradually shrink all to the breadth, while the next plank, shown in Fig. 9, clearly points close to the centre or heart of

FIG. 9.



the tree, where it will not shrink to the breadth but to a varying thickness, with the full dimensions in the middle, but tapering to the edges, and the planks on the right and left will give a mean, but with the centre sides curved round, and the outside still more hollow.

The foregoing remarks apply more especially to the stronger exogenous woods, such as beech, oak, and the stronger home firs. The softer woods, such as yellow pine, are governed by the same law, but in virtue of their softness another law comes into force, which to some degree affects their behaviour, as the contracting power of the tubular wood has sufficient strength to crush the softer medullary rays to some extent, and hence the primary law is so far modified. But even with the softer woods, such as are commonly used in the construction of houses, if the law is carefully obeyed, the greater part of the shrinking, which we are all too familiar with, would be obviated, as the following anecdote will serve to show. It was resolved to build four houses, all of the best class, but one of the four to be pre-eminently good, as the future residence of the proprietor. The timber was purchased for the entire lot, and the best portions were selected for house No. 1, but by one who did not know the law, and to make certain of success this portion of the wood had an extra twelve months' seasoning after it was cut up. The remainder of the wood was then handed over to a contractor for the other three houses, who had an intelligent young foreman who knew the structure of wood as well as how to obey the law, and who, therefore, had the wood for the three houses cut up in accordance therewith. The fourth house was built the following year by another man, but long before ten years had passed, and to the great surprise and annoyance of the proprietor, it was found that his extra good house No. 1 had gone in the usual manner, while the other three houses were without a shrinkage from top to bottom. As Solomon says, "Wisdom is profitable to direct."

A similar want of correct knowledge of the natural figure and properties of the structure of wood, such as the oak, is constantly shown by the imperfect painting to resemble that wood, as exhibited on the doors and shutters of many of the houses of this metropolis. If

we cannot afford to have genuine wainscot doors, as in France, but yet desire to have an imitation, it would surely be worth the trouble to have a block cut from the quarter of an oak tree, and to have each of its six sides planed and polished, in order to make plain their several features. The house-painter would then see what nature really is, and thus save us from the ridicule of other nations, when we mix up "silver grains" and all the other natural features upon one side of a board or panel.

Before proceeding to the consideration of the metallic properties, let me enumerate some of the leading characteristics of iron in a few words. Cast-iron is the metal as extracted from the earthy ore. As a rule it is extremely impure. It contains, besides other substances, from five to two per cent. of carbon, partly in chemical combination, and partly free or uncombined; its ultimate strength varies from about five to fifteen tons per square inch, according to quality, the average being between seven and eight tons, and its limit of elasticity is not far from the third of its tenacity, and most frequently is in the vicinity of from three to four tons per inch, but more generally under than over; it has scarcely any malleability; it is more brittle than tough or ductile; as a general rule, still, by certain mixtures, its toughness or ductility, or elasticity, may be greatly augmented. Its great redeeming quality is the property that it can be so readily melted into the liquid state, so that it can be poured into a mould like water, thus enabling us to obtain castings of any form or dimensions with the utmost facility. In a general way, the fluidity depends mostly on the proportion of carbon present in the alloy; hence, with an abundance of carbon, it becomes so liquid and so thin as to run freely into the most intricate forms required in art, and the slight increase of volume that takes place at the moment of crystallization into a solid, has the effect of still further giving a sharp impression of the ramifications of the mould.

Wrought-iron is made from cast-iron by a process of purification through the flame of a furnace, thus freeing it from the greater portion of its carbon by oxidation, down to one-quarter per cent. and under, and sometimes even to a state of almost purity. This elimination of carbon and other substances, combined with working under the hammer or rolls, produces a great change in its nature; it has lost the property of becoming a liquid, but it has acquired the almost equally important one of being weldable, that is to say, by heating two pieces to a certain high temperature, which produces the viscous condition, they may be united into one piece by pressure or hammering, that is, if the metallic surfaces are perfectly clean. By this change the strength of the iron is increased to about eighteen tons in the inferior sorts, up to twenty-eight tons in the higher qualities, with an average tenacity of twenty-two or twenty-three tons per square-inch; the limit of its elasticity varies from about eight tons up to twelve tons, but generally it is a little under ten tons; it has also acquired the property of being tough, ductile, and malleable.

Steel may be described as a nearly pure iron, chemically combined with a nearly pure carbon. The best qualities are made by placing the finest wrought iron in a refractory box containing charcoal, which is kept at a red heat for about a week. During this period the carbon vapour is infused into and amongst the iron molecules, and it gradually becomes what is termed from its appearance "blistered steel," which can not only be hardened, but can, by well-known means, be united to cast-iron or welded on to wrought-iron, and is frequently so used where rigidity and hardness are required, such as for the face of a smith's anvil, or the faces of hammers and such-like instruments of the ruder class; and when this blistered steel is drawn down under the tilt or steam hammer, it is then called "shear steel," and is used for all kinds of ordinary cutlery, swords, springs, and such like. But, for more particular purposes, these bars of blister steel are broken up into small pieces, and melted in a crucible into the condition termed cast-steel; the

impurities float to the surface, and are skimmed off, the steel is then poured into ingots, and then hammered or rolled into bars, or otherwise, as may be required, and by this means the most of its remaining impurities are eliminated. Such steel is used for the greater number of purposes where the highest excellence is essential.

Steel varies greatly in regard to its steely property, and depends on the amount of carbon which has been infused into the iron, and this varies from about $\frac{1}{4}$ per cent., in the so-called mild steel, up to 1 per cent., or even higher, in the stronger qualities. Steel is made by various other systems, such as the Bessemer process, but it is not my present purpose to explain them, the ultimate object of all being the same. Other methods reach the goal by a more "rough and ready" path, consequently they are cheaper, but they have not the fine qualities of the best cast-steel.

The strength of iron is much increased by the introduction of carbon, to give it the steely property. The strength of the lower quality, called mild steel, ranges in the vicinity of 30 tons per square inch, and in the higher qualities it reaches to 75 tons in its natural state, and this, by certain processes, may be raised to 120 tons. Steel is distinguished not only for its strength, but also, in an equal degree, for its fineness and closeness of structure, and, above all, for the wonderful property that it may be softened or hardened, made tough or brittle, or modified, so as to render it suitable for the varied and innumerable purposes required by man, and more especially in the engineering workshops of modern times, where its use is indispensable.

Although the metals differ greatly in regard to their density, still the porous property is much less observable than it is with wood, and it is only occasionally that we find the passage of water through its pores. This, however, will take place sometimes in the case of soft cast-iron in a great mass, and with the water at several tons pressure per square inch; then the water may be seen like dew all over its outer surface; it is the same even with gun-metal bronze in forcing pumps, that is if an improper mixture of copper and tin, and imperfect treatment have been employed in their manufacture.

The mixing of two distinct metals into an alloy such as copper and tin, gives greater density to the compound; the alloy called gun-metal consisting of $90\frac{1}{2}$ copper and $9\frac{1}{2}$ tin, occupies a volume smaller by $\frac{1}{15}$ than the two taken separately; this is on the same principle that, if a pint of oil is mixed with a pint of water, the result will not be equal to two pints. It would appear that the molecules, or fine particles of the tin, find their way into what may be considered as vacant spaces in the copper, and the result of this mixture is to improve the metal in most respects, with the exception of malleability and ductility.

Of late years the subject of mixing different kinds of metal in certain proportions, in order to obtain higher qualities for particular purposes, has had great attention; for example, a mixture consisting of 60 parts of copper with 40 parts of zinc gives great malleability and a tenacity of from 20 to 22 tons per square inch, nearly the double of what the metals give when taken separately, and even this mixture of copper and zinc, with the addition of 4 of iron and 2 of tin, gives another remarkable compound still more dense, particularly suitable for gun purposes, barring the expense, and no doubt man will yet find out many other instances to meet his ever-increasing wants.

But still more remarkable is the density arising from mixing different sorts of alloys of the same metal, say cast-iron. A numerous mixture of sorts gives a denser and stronger metal than the average of all taken separately, and advantage is greatly taken of all these properties in order to obtain the quality of iron best suited for particular purposes, so that cast-iron alloys of proper selection may thus be obtained of almost any tenacity between five and fifteen tons of ultimate strength, and with the other requisite properties varied to suit the intended purpose.

Another peculiar feature of some of the metals in this respect is the fact that, apparently, they can be rendered more dense, or at least closer in molecular structure, by other means, such as by pressure in a fluid state, which seems to compress gas vacancies in the mass, or this may be accomplished in some metals, such as copper, by pressure when in the cold state, as by rolling or hammering. During the past year or two, Mr. Whitworth has been making a number of valuable experiments in subjecting fluid steel to hydraulic pressure, so as to increase its density and strength for gun purposes. For hundreds of years founders have used pressure for the same purpose, in what is called a "dead head," that is to say, a column of fluid metal rising several feet higher than the casting, thus giving, if desirable, an extra pressure of about 15 lbs. per square inch, and an extra opportunity for the gas bubbles to float upwards; but in Mr. Whitworth's experiments the pressure is increased to several tons per square inch, and the engineering world is looking forward with great interest to the result, as, if successful, it will open up a new field for investigation; for thus it is that science advances, little by little; when it once gets a firm hold of an idea, a law, or natural property—first the idea or proposal, then the course of experiments, at length the world-wide application.

The rendering of metal more dense, or of closer structure, by means of pressure or hammering when in the cold state, is observable all through the arts. The copper for utensils, such as a teakettle, is subjected to a hammering process called "planishing," and may be made so compact thereby as to be suitable for a spring for gun-powder machinery instead of (for that purpose at least) the more dangerous metal steel. Even soft wrought-iron is frequently treated in the same manner, and used as a spring, but wholly on account of its cheapness, and it is much inferior to steel for spring purposes. Compressed lead-bullets are denser than cast bullets; they have fewer air or gas vacancies, and invariably have the preference on that account, but it is not clear that the actual molecules in contact are susceptible of being pushed closer together.

In the boring of brass guns, in order to condense the interior, the last boring instrument makes the bore about the tenth of an inch smaller than the required dimensions. There is then introduced a blunt instrument, called a "condenser," which, as the gun revolves, is forced along the bore, thus enlarging the bore to the proper size without cutting away the metal, that is to say, the metal is sufficiently porous to admit of the inner surface being pushed outwards, yet without the condensing effect reaching the outside so as to enlarge the exterior diameter. By this means a harder and stronger interior is given to the bore, and the operation affords a good illustration of Professor Tyndall's theory, as the heat developed is in proportion to the motion of the molecules. Even a piece of steel can be rendered more dense. This is shown by an interesting experiment which is sometimes made to test the properties of malleability and resistance to compression. The specimen is in the shape of a small cylinder of steel, which is put under a testing machine with pressure sufficient to flatten it down very slowly into a button form, and nicely rounded on the edges; the original ends are now, in the centre, of a larger diameter, yet without separating the atoms. It thus acts as a liquid, the ends being in the centre is due to the friction on the compressing surfaces, and from the increased density, with the effect of motion in the particles, it has acquired greater strength than it possessed before the distortion of form and the changing of relationship of the particles. Even with those who are dealing with such metals daily, and still more those who are not so much accustomed to see the flowing properties of solid metals—this movement of the so-called solid particles amongst each other like water or tar—this remarkable property may not have excited their attention so much as the subject deserves. To my mind it is one of the most

wonderful things in nature that are to be met with in our workshop treatment of the metals, and which will now be shortly considered under the natural properties of malleability and ductility.

In order readily to understand these two remarkable properties of malleability and ductility, which are now turned to such good account in almost every branch of the mechanical arts, it will be convenient to think of the malleable or ductile metals, such as lead, tin, copper, wrought iron, and steel, as substances that can be moved about like dough, that can be spread out as with a roller, that can be elongated by drawing out with the hands, that can be squirted through a hole by pressure like macaroni, or even that the dough can be pushed or gathered back again into its original mass of dough, that is, if proper means are employed to perform the operation gently, and this may be done without breaking the continuity of the particles of which the mass is composed. Such a statement may well seem fabulous, but it will be my province now to enumerate many things in connection with metal much more wonderful than what I have said regarding the dough, and even more strange than the change in dough when overtaken by the biscuit state from the baking process.

It is difficult to understand the possibility of the malleable and ductile properties without fully realising that their particles are fluid, in a certain sense, and that this is due to the molecular arrangement, not so fluid as water, tar, or bitumen, but still a fluid which will flow in obedience to sufficient pressure, and just as those fluids require time when acted upon by gravity, so the metals require greater time and more force than gravity, the rate of flow being determined by the nature of the metal, the softer metals requiring less pressure and flowing faster than the harder; and in the case of steel the flow is extremely slow, but with pressure, time, and patience, it also may be overcome, and made to flow gently, into any shape or form, while in the solid condition.

For a number of years the flowing property of the softer solid metals, such as lead and tin, has been taken advantage of very extensively, in the squirting of pipes and otherwise, and for thousands of years the malleable and ductile metals have been under treatment by man, and a vast number of practical facts have been thus accumulated, but it is due to M. Tresca, of Paris, to say, that he has done more than, perhaps, any other man in regard to the investigation of the natural laws by which the flow of solids is governed under varying circumstances, and the most interesting point of all is the great similarity that exists between the flow of solid metal and that of the flow of water—that in the flow of solids from an orifice there are the same converging currents, eddies, and that the quantity of metal issuing is dependent on the same conditions as water when issuing from orifices of different arrangement, and only differs in degree.

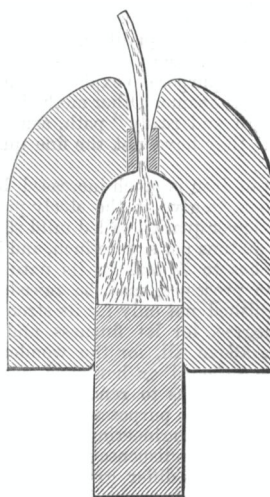
From time immemorial man has been familiar with gold as a flowing metal, both as malleable and ductile. It is in consequence of these properties that gold may be beaten into leaves so thin that it takes 290,000 to make one inch in thickness, or it can be drawn into a wire so fine that an ounce weight would extend a distance of fifty miles. The flowing action which takes place in coining a sovereign or other coin, is very apparent. This process is not the mere stamping which it is generally considered to be, but the particles of the gold have really to flow in the same manner as a liquid, from one part of the die to another, in order to fill up the deeper recesses of the die from the shallow part of the space, and so form the perfect coin from the rush of gold penetrating everywhere. As, however, gold is not one of the most common metals of applied mechanics, its presence in the workshop is less seldom met with than some of the others which have been already enumerated.

The metals lead and tin are both malleable and ductile, but their malleability, or spreading-out property, is

much greater than their ductility, or drawing property, and both being soft, and having the flowing property in a pre-eminent degree, they can thus be squirted or rolled to any extent, or into any form of pipe or sheet, so that the want of ductility is scarcely felt.

The diagram (Fig. 10) will explain the nature of

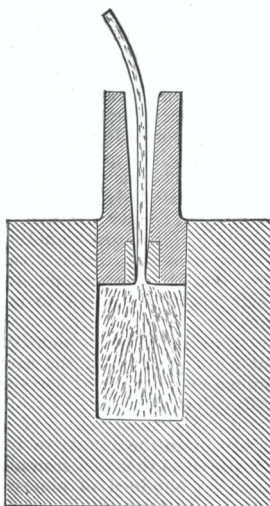
FIG. 10.



apparatus which is employed to squirt these metals when in the solid state. It is a powerful syringe filled with solid metal, with pressure on the piston varying according to the dimensions; in some the force required is 2,000 tons. In the earlier machines the arrangement was exactly the same as in an ordinary syringe, as shown in Fig. 10, but it was found that the fluid pressure of the metal within the syringe created such an inordinate amount of friction upon the inner surface as to rapidly wear out the several parts; but by a slight modification, more in accordance with sound principles, the defect has been obviated.

In the arrangement shewn in Fig. 11, the piston

FIG. 11.



contains the orifice, and in pressing against the upper

surface of the metal, causes it to remain in a state of rest within the containing vessel; but as fluid pressure is equal in every direction, the solid finds the orifice as a point of less resistance, hence it flows outwards in a continuous stream, thereby avoiding the friction of the solid lead within the cylinder. It will thus be observed that a rod of lead or tin can be squirted of any form or dimensions, depending on the die or orifice. In the Royal Arsenal may be seen lead thus squirted into continuous rod, and then wound upon reels like yarn, to be again unwound and made into bullets by self-acting compressing machinery; but the whole of the several processes are entirely due to the flowing property. Man's mechanism is very subordinate, and may be varied to any extent as circumstances may require.

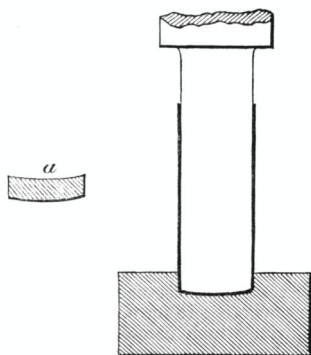
Pipes are made with the same facility as rod, by the mere insertion of a steel pin, the size of the required bore, placed in the bottom of the cylinder, and exactly in the centre of the orifice, thus forming an annular space through which the metal flows outwards as a continuous pipe; or, by making this pipe of sufficiently large diameter, and then cutting it open by a stationary knife as it leaves the machine, the pipe becomes a sheet of lead, which, by means of suitable rollers, may be wound on a reel as a long web of sheet lead, or the sheet lead may be rolled out by rollers. In both ways the same mechanical work has to be done; the respective friction is a disputed point.

A very singular result was obtained by an attempt to squirt brass pipes, which are extensively used as steam boiler tubes and for gas-fitting purposes. This brass consisted of 60 parts of copper and 40 parts of zinc, and of various other proportions, but, singular to relate, the pipes so squirted were zinc rather than brass; the most of the copper remained in the vessel, and refused to flow. We are not to infer from this that the copper would not flow, but rather that the union between the zinc and the copper was less than the pressure necessary to make the copper flow, the mixture may have been more mechanical than chemical, or the temperature may have been such as to have had the zinc too near its melting-point. Whatever is the explanation the subject is well worth further experiment. In all such operations, the nearer the lead or other metals are to the liquid state, the easier it is accomplished, but it must be solid.

Lead or tin may be rolled out to any extent, either singly or both combined, or with a thin coating of tin or other metal upon one or both sides of the lead, so as to have a leaden substance, but yet covered with a tin surface, perhaps not thicker, if so thick, as the leaf called tin-foil, thus combining economy with scarcely any disadvantage, for many purposes.

A beautiful illustration of the flowing property of tin is shown in the manufacture of the German capsule, in which the paint for artists is made up for sale and use. A button of tin, as in Fig. 12, is laid in the recess of a

FIG. 12.



die in a fly press; a corresponding punch or die, a little smaller, is then brought brought down upon it with a smart blow, thus leaving, from the difference of dimensions, an annular space between them, when the metal at once squirts upwards like water, but at a velocity much faster than the eye can follow, thus converting it into a perfect capsule. The form of the punch and die depends on the article to be made, but in all provision has to be made for the admission of the atmosphere on the removal from the dies.

From these remarks, it will be seen that, by understanding a few of the natural properties of these metals, how completely they are under man's control, and by knowing the simple laws, he can modify the apparatus in thousands of different ways, in order to produce whatever may be required.

We next have to consider the flowing malleable and ductile metal, copper, which has these several properties in a high degree, and, from its subserviency, is turned to great account in the arts. This metal may be rolled into sheets of extreme thinness, or, by suitable means, drawn into pipes, or worked into other difficult shapes, but I shall only select one or two illustrations of what can be done with this metal by a course of kind and gentle treatment, for on this success entirely hinges.

In the sugar and other manufactures there is a demand for large copper vessels, some nine feet in diameter, of hemispherical form, with a flange like the brim of a "wide awake" hat, turned outwards around its edges. Now, the mass of copper to form this immense pan is made to flow gradually outwards into this shape by a process of first rolling, and then, after arriving at a certain stage, by a continuous hammering, thus working the pan out of a single disc of copper. Supposing this disc to be like an immense cheese, some four feet in diameter by six inches in thickness, let us try to realise the condition of the particles of which this copper cheese is composed, and which have to work their way outwards, continually parting with and forming new relationships, but still particle holding on to particle, although sliding about and amongst and away from each other, until they at length have become a thin hemispherical dome, without a flaw or single break in its continuity. Let us more closely consider this process for a little. The mass of copper to be operated upon is composed of extremely small molecular particles arranged in crystals, held together by the still mysterious property of cohesive attraction. If the mass were composed of water, or even tar, the effect of gravitation would be to spread it outwards into a broad, thin sheet of tar or water, or even into a mould the shape of the pan, but as the copper is not so fluid, and more tenacious than those substances, it requires a corresponding force or pressure, immensely greater than gravitation, in order to make the particles of copper flow. The first operation is by rolling the mass between two powerful rollers, the effect of which is to cause the metal to flow out in the direction in which it is rolled, but not to the sides; this is on account of the friction it meets with from the surface of the rollers, but for no other reason. This elongation, by spreading out longitudinally, tends to elongate individual molecules and crystals into fibre, and, if the rolling were repeated always in the same direction, it would become fibre visible to the eye. This is not done, however, in the present case. The mass is then passed through the rollers another way, namely, at right angles, thus breaking up the former fibre into fibre in another direction, and by repetition, long fibre in a particular direction is avoided. After this rolling has been repeated for a number of times, a change begins to come over the fluidity of the mass, just like the dough becoming biscuit; it is less willing to move, it has become much harder and more brittle than it was at the commencement, and if the rolling were persevered in, it would soon crack at the edges. This change from free to rigid arises probably from the increased density and closeness of the molecular structure, resulting from the movement of the

molecules upon each other; but now another law of nature is brought to bear upon the metal. It was found out long since that if metal in this hard state is heated to a certain temperature, somewhere in the vicinity of a red heat, that the frozen particles are at once liberated from this condition of restraint, and have again resumed their former fluidity or malleability, and are again equally ready for work. This valuable process is called *annealing*, and is one of the great discoveries of past ages that have been handed down to us; it is invariably resorted to in all such processes, and need not, therefore, be always repeated in my descriptions where it is resorted to. By repeated rolling and annealing the mass is spread out into a large thin disc, with all its particles in continuity, and if it served any useful purpose, by means of a suitable apparatus and plenty of patience, it could be made to flow back again into its original condition of mass by a gathering-up process, but that is not the object in this case; it has now to be worked or curved round into an immense hemisphere. To accomplish this the steam hammer is employed; the hammer for convenience is set upon a transverse overhead girder structure, so that there is perfect freedom on the floor of the workshop for the manipulation of the pan all round a small convex anvil, which is fixed at a sufficient and convenient distance from the floor. The pan is suspended by means of a sling from a swing crane, so that the workmen may move the copper-pan about freely upon the anvil, while the steam hammer is at work giving light blows in rapid succession all over the necessary parts of its surface, as guided by the skill and knowledge of the workmen, in order to bring it gradually and approximately into form, and of uniform thickness. By this time the metal is gradually becoming thin, and hence more easily made brittle, when an extra blow on any given part might be one too many, which, of course, would destroy the whole by breaking up the continuity of the copper, to prevent which the annealing process is resorted to again and again. The pan is now probably too large for admission into the annealing furnace, but man is ever ready with an expedient when he knows the principle. A hot blast as a substitute is now directed upon the brittle parts of its surface, and thus the malleable quality is again restored, and so by successive hammerings and annealings it is at length completed.

Looking at such a hemisphere, and then thinking of the dumpy mass of copper from which it came, it would be interesting to trace the path by which the remoter particles have reached their present position, and to unravel the wonderful relationship which exists between them severally, if any; or how many partings of friendly molecules took place by the way; or if any, how many new connections were formed with other molecules. However it may be, we find the same tenacity and strength to be still maintained throughout the entire mass, and that any change produced is for the better in all respects. It will also be observed that all this is in accordance with and depending on the natural properties, and in virtue of natural laws. Even the steam hammer itself is a gravitation hammer more than it is a steam hammer. Heat or steam is merely another power of nature employed by man to raise the hammer from the anvil, that is, to overcome gravitation, for, when left to itself, it falls in obedience to the law, and expends its work upon the anvil, and, just like the molecular structure of materials, it is simply attraction and repulsion acting in another way. Man's part is to apply nature.

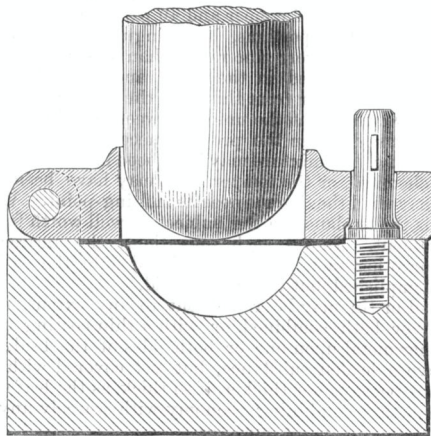
For the same or a similar object, there is another class or principle of apparatus extensively used in the mechanical arts, under many modifications, whereby the solid fluid is made to flow in a more definite direction, by having it so enclosed within dies or otherwise, in which it is thus constrained to move, provided that sufficient external force, given by increments, which is brought to bear upon the piece of metal under treatment, and by means of which most marvellous results are obtained, but only when the means employed acts

gently on the metal under operation; indeed, this is the whole secret of success. At the present time a great amount of attention is being directed to the best modes of obtaining the flow of metal into other forms, yet without disturbing or distressing the material of the flowing solid. Three typical illustrations will suffice to show the principle, and although dissimilar as regards the conditions of apparatus, they all agree in the grand leading feature.

There is a great manufacture carried on in Birmingham and elsewhere, whereby flat sheets of solid copper or iron are constrained to flow into a mould, in order to form hemispherical or other shaped basons of various sizes. This may not seem a great feat, after describing the making of the large sugar pan, still this is a much more difficult operation, and can scarcely be credited, from the circumstance that a disc of the proper thickness or substance has to be at once pressed into the hemispherical form, and yet without puckering the metal at the edges. If we try to press a sheet of soft paper into such a shape or form, such a result in iron will seem almost an impossibility, and it is only by keeping in mind the natural or moveable property of the molecules of the malleable metals, that the particles thereby can be pushed in amongst each other, or drawn, or spread out, and all with equal readiness, from such considerations the impossible vanishes to some extent.

The diagram (Fig. 13) will explain how this is accom-

FIG. 13.



plished. There is first a block or die containing a recess the shape of the required article, with another suitable recess on its upper surface wherein to hold the flat disc of sheet iron or copper; then there is placed on this disc a folding plate, which is fastened in such a manner as to grip the metal disc firmly, but yet not too rigidly. A corresponding die or plug is made to conform to the lower recess, and this is pressed or driven downwards through a hole in the upper plate, thus acting upon the surface of the iron disc, and forcing it downwards into the lower die as prepared for its reception, until it finally reaches the bottom. But what becomes of the irrepressible puckering? It is almost entirely prevented by the presence of the upper plate, which only allows the solid metal to flow over in an even stream like water over the edge of a fountain, the force of the pressure being sufficient to overcome the friction of the upper plate, as well as moving the particles, and the flowing character of the molecular particles thus adapt themselves to the new circumstances, there being no empty space for the puckering to form, and most remarkable of all, even the brim, which came from the large diameter of the original outside, scarcely shows a pucker in its now altered dimensions, for when the dish is turned out

of the die, the brim is of a smaller diameter than the original disc. What an amount of movement amongst the molecules this implies, inwards and outwards.

A second illustration of this constraining principle is afforded by the die system of striking up ornamental articles in deep relief, and of almost every description of pattern as mostly used for various purposes in dwelling houses. To accomplish this great change a series of dies are employed in succession; the thin sheet of metal is laid in a pair of dies, No. 1, when a falling weight drives them together, thus stretching or setting in the sheet only just as much as it will bear at one operation; it is then put into another pair of dies, No. 2, which is still deeper in its recesses than No. 1, and there receives another blow which carries it a little farther; thus by frequent annealings and change of dies, repeated again and again, almost any form may be struck up, the united result thus gradually producing deeply embossed articles, but to produce which, sometimes as many as twenty dies will be required in succession.

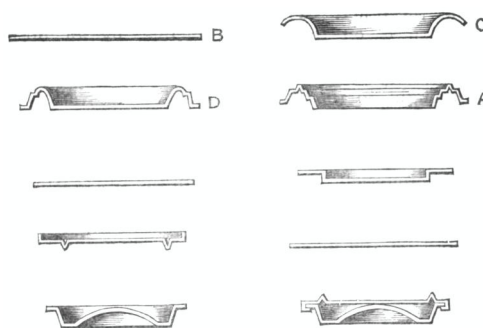
The principle of working metal into form by a series of dies in this fashion, was discovered about eighty years ago, and was considered at the time to be a perfect marvel of ingenuity; and if it fails to excite our wonder, now that our minds are familiarised with the working of metal, it only shows the advance that has been made in the general knowledge of this branch of the art, and from this may be inferred that our young workers are more likely to rise to a higher platform than that which we have reached.

There is yet another typical system of operations of this class for altering the shape of malleable metals, namely, that of causing the sheet metal to conform or flow into hemispherical, oval, or irregular forms by motion, which was invented in France a few years ago, but which is now extensively adopted in England. The process is called "spinning," and is rapidly superseding the die-stamping method wherever it can be employed advantageously, because it acts more kindly on the metal. It is the result of gentle pressure combined with rapid motion, and involves a great principle; the effect is due to motion in connection with time. The chief feature in all such changing of form, is the giving sufficient time for the particles to move or flow. To press the flow too rapidly would cause the sheet to tear from rupture of particles. In the operation of spinning, this tendency to tear is defeated by communicating a very rapid circular motion to the sheet of metal, and then by means of an instrument or instruments held in the hand, a gentle pressure is brought to bear on one point, thus causing a slight depression, but as the sheet is spinning at a high velocity, the depression at once forms a circle, and so by continuing the pressure of the instrument it is moulded into any form accordingly.

The operation of spinning is performed in a species of lathe. A mould of the required form is generally fixed on the end or face plate of the revolving spindle; the sheet or disc of metal is held by pressure from another head-stock against the mould, and thereby the local pressure of the instrument is thus adroitly formed into the shape of the mould behind it.

On the table before us are specimens of the progressive manufacture of the lids of powder-cases, as they are made in the Royal Arsenal by this principle of operation, termed "spinning," by examining which, its nature will be understood; it will also be seen how much change of form, or rather movement among molecules, is requisite to produce the rigid or brittle condition that necessitates the annealing process, in order to restore the malleable and ductile property, which is required to still further change the shape. There is first the entire mouthpiece of the case in the form, here shown, in Fig. 13a, ready to be attached to the flat surface of the case top; the stationary part has reached its present peculiar shape, A, through five stages. It is first cut into the flat disc, B, then the disc is spun so far as C; it is now requiring to be annealed, and, after this, it is turned into the

Fig. 13a.



third condition; it is then spun into the fourth stage, D, and from that to the finished article, A. The lid which fits into A is composed of two separate pieces, both made by spinning from discs, and both pieces, when complete, are united by spinning over a lap of one upon the other. It will be observed that certain corrugations are produced by the process; these add greatly to the strength, but scarcely anything to the cost. It will also be seen how nicely the lid fits into the mouthpiece; this nice fit does not depend on the workmen, but wholly on the mould in the lathe, from which it is correctly transferred by copying, by the pressure of the spinning instrument.

The French, who were the originators of the process, employ it with great dexterity in a variety of ways, more especially in the production of such articles as large oval dish-covers. The sheet is secured to the centre of what may be called an oval chuck, and by a dexterous use of two pieces of greased box-wood held in both hands, the workman very cleverly prevents the sheet from puckering as he spins it into an oval, and finally turns over the outer edge into a border, thus giving it rigidity as well as a neat finish. The time required for the operation is so short as to be scarcely credible, and has to be seen to be appreciated.

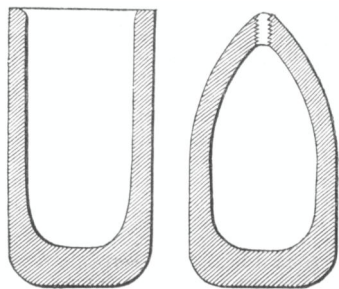
The metal wrought-iron, as used by the smith, is also exceedingly malleable, both hot and cold, but especially when it is hot. All are familiar with this metal in the condition called "tinplate," which is a thin sheet of iron spread out with rollers, afterwards cleaned, then covered with tin as a preservation from oxidation as well as for appearance, besides the facility which it affords for being united by solder in the hands of the tinman.

In the Great Exhibition of 1851, a foreign exhibitor had an iron book, in which the leaves were made of iron as thin as tissue paper, and iron may be seen of any substance or shape, every variety of bar, or, worthy of Vulcan, up to armour plates of fifteen inches in thickness or 25 feet long, 5 feet wide, and 8 inches thick, as made at the well-named "Cyclops" Works. Iron or steel may be drawn into gun-barrels like dough over a mandril, but one of the most marvellous illustrations of the malleable, ductile, and flowing properties of wrought-iron is shown by the manufacture of quicksilver bottles. These bottles are made in various ways; in the process referred to the bottle is made out of a circular disc of iron plate, which contains the quantity of iron necessary to form the article. By the stamping process already described, the disc of iron is gradually brought round to be of a cylinder shape resembling the form of drinking glass called a tumbler. This cylinder is then put upon the end of a steel pin or mandril, and, by mechanical pressure, is pushed through a hole, which hole is smaller than its own dimension, thereby reducing its exterior diameter, but at the same time drawing or rather pushing the iron over the mandril in the same manner as a piece of dough could be drawn over the finger to fit like a glove. This process is repeated through a succession of smaller and smaller holes, one after the other, until at

length it becomes a long cylinder, close at one end but open at the other. The neck of the bottle has next to be formed on the same principle, by an often-repeated pressing and twisting at the open end into a conical die, by which means it is gradually and successfully brought to the form of the bottle neck, in which a screw is afterwards formed for the stopper by the ordinary means.

During the Crimean war, a large manufacture of wrought-iron shells was carried on in the Royal Arsenal, not precisely, but nearly in the same manner. They were made in an elongated form, and of an oval section, as shown on the diagram, Fig. 14. These shells were

Fig. 14.



made out of a single piece of iron, in which, to form the cylinder, welding was so far employed, but were then brought to the bottle shape by what may be called hammers. The mouth of the shell was attacked simultaneously by a circle of hammers, whose united surfaces afforded the required shape, while the other parts of the machine prevented the shell from flinching during the operation, and thus it gradually came into the required bottle shape without any puckering, which most men would previously have expected. Such a result was entirely due to the uniform effect of the combination of hammers, thus constituting a sort of die.

The elongation of a quicksilver bottle over a mandril partly anticipates the nature of the ductile property, yet not entirely so. Ductility is that natural property by means of which a solid substance, such as iron, steel, and other metals, can be drawn or pulled out to almost any degree of fineness. This property, although often accompanying malleability, does not do so in some cases, such as in lead, possibly for want of tenacity, as lead can be squirted into a thread of any fineness by pressure. This natural property of ductility is taken advantage of to produce endless variety of form, but in all the mechanical principles employed are nearly alike—namely, to pull the metal through a rolling or stationary hole, and thus to alter its form or dimensions.

To take the simplest and most familiar case, that of common wire-making, the iron or other metal is first rolled out into a long bar of small diameter; the end of this bar is reduced in pointed fashion so as to enter a conical hole in a steel "draw-plate," as it is termed, the hole being smaller than the remainder of the bar; a pair of pincers worked by machinery seizes hold of the small end of the bar; the draw plate is held rigidly; then the force applied is sufficient to overcome the unwillingness of the particles to move, but the flowing property permits the change, and the iron rod is thereby drawn out into a smaller and longer wire, which is repeated through smaller and smaller holes in succession, with occasional annealing, until at length the requisite fineness is arrived at. From this it will be seen that the shape of the wire depends on the form of the hole in the draw plate, and may be to any pattern—sprigs of flowers for the calico printer, toothed pinion steel wire for the watch and clock maker, or even tempered steel wire of all sizes for the pianoforte maker.

Wire has been used in Europe for more than 400 years. At first it was made by drawing down, in blacksmith fashion, with the hammer upon an anvil. The draw-plate was invented in Germany about 300 years ago, but it was comparatively little used until recent times. Now, the rolling-mill and the draw-bench are combined into one system of manufacture, by means of which the rate and diminished cost of production have developed the trade so enormously as to have led to the use of iron and steel wire for ropes, bridges, fencing, telegraph, and so many other new purposes, that it has at length become a great branch of industry.

Hollow tubes are now manufactured of all sizes, and out of all the ductile metals. This apparently difficult process is accomplished in several ways. With one system it is done by first forming a hole through a short, dumpy piece of metal, either by casting or drilling; into this hole a mandril is inserted, and then the dumpy mass, by means of the drawing process or by rolls, is passed through a succession of holes until it covers the mandril from end to end. This mandril may be a fine wire, or large enough to form the tubes for a steam boiler. A similar process, but substituting rolls for the draw-plate, is mostly employed for the larger sizes. The same or similar principle is frequently employed to make tubes, close at one end, these tubes being of various sizes; in such case the holes are not passed entirely through the mass; the mandril is inserted, and is then pushed through the successive holes in the draw-plate, until the metal is extended over the mandril. Sometimes the piece is formed from a disc into a thimble form, and then put on a mandril to be elongated. There is also an extensive manufacture of iron wire and of iron tubes, both being covered with a thin brass tube, by which means not only beauty but greater strength is obtained at a reduced rate; and for such purposes as these articles are used, viz., picture-rods, hand-rails, shop windows, carpet-rods, and such like, the arrangement fulfils the object equal to an entire brass structure. The iron-wire or tube is made as before described; the outer brass tube is made in a similar manner, but sufficiently large to admit of its being slipped over the iron. The iron may now be considered as a mandril, and the two are drawn through the draw-plate together, thus fixing the thin brass tube upon the iron, while the whole surface exposed is brass.

The so-called copper wire which is now extensively used by upholsterers for the spring cushions of sofas, beds, and similar purposes, is merely iron wire, which is made in the ordinary manner until just before the last process, when it is immersed in a solution of sulphate of copper for a short time, sufficient to allow a thin film of copper to be deposited on the surface of the iron wire. The iron wire thus covered with copper is now drawn through a draw-plate, by which it is rendered hard and elastic, and suitable for a spring, at the same time the dull surface of the deposited copper is made as bright as a new farthing, and serves to protect the wire from oxidation.

There is yet another application of the natural law, which a few years ago would have been reckoned an impossibility, it is the process for drawing conical tubes. Nothing yet said will explain how this can be done. A taper mandril will suggest itself, which, so far, is simple. But the die of varying diameter, how is that to be obtained? For a long time rolls for rolling taper gun-barrels have been in use, in which a succession of tapering grooves are formed, while, by dexterous management, the roller contrives to insert the thick end of the gun-barrel at the precise point in the revolving rolls, and thus the gun-barrel is elongated towards the muzzle by means of the narrowing groove in the rolls; bayonet blades are likewise drawn out in the same manner. In the process to which I now refer, for the drawing out of the long tapering brass tubes, an expanding die is used for a draw-plate. This die consists of a ring of block-tin, containing a small per-centage of copper, to give it a little greater rigidity; this ring is applied at the smaller end

of the mandril, and the brass is drawn through the die. By this means two effects are produced, first, the metal is drawn over the mandril to a small extent, and, secondly, the die is destroyed, from the extension to which it has been subjected; it is therefore thrown into the melting-pot, to be cast into a new die, and thus, by a succession of new dies, the metal is gradually drawn over the steel taper mandril, until it is covered with brass from end to end, when the steel mandril is withdrawn.

There is yet another remarkable process in connection with this natural property, which is taken advantage of in the formation of ornamental twisted tubes of various patterns, such as we see in the gas fittings of churches and other places. To produce such tubes, the brass is first drawn into a plain tube upon a mandril, in the way described; this plain tube is then passed through a succession of revolving blunt screw-tools, having the required form upon their interior surface. In form the tool is arranged as a screw nut, but not being adapted to cut the metal, and the plain tube being without a mandril, its surface is slightly depressed by the screw pressure, and by a succession of such screw-tools, or nuts, it is finally depressed to the finished ornamental pattern as required.

We sometimes see these ornamental tubes of a diamond screw pattern, where the spiral is crossed by another spiral, uniformly along the entire surface. This is done by means of two sets of screw tools, one set turns to the right hand, the other set to the left hand, and between the two the pattern is formed. This pattern may be of any section, plain, square, octagonal, ribbed, rounded, or otherwise, all depending on two principles, first, the flowing properties of the atoms of the metal, and secondly, the copying arrangement, by which the required pattern is transferred to the tube under operation, thus shifting the relative position of the molecules, yet without cutting the metal.

Referring again to the wire-drawing process, such is the effect produced by the operation that, contrary to what might have been expected, the strength of the wire or steel is greatly increased. In the case of iron of an ultimate strength of 25 tons per inch, it is increased in strength fully 10 tons, and some of the best iron, with a strength of 28 tons, is raised to 40 tons. The most remarkable change in this respect is in the case of steel music-wire. The mild steel out of which this is made has a strength, when in the natural state, of from 30 to 40 tons, according to its steeliness, but when tempered mildly by being made red-hot and then cooled in oil, and elongated into wire, its strength is increased fully threefold. At the same time, if such steel or even iron wire is made red-hot, so as to allow the natural law to assert itself, all these high conditions vanish, with only one redeeming quality, that the wire then becomes more pliable, and similar in strength to the iron or steel out of which it was made.

The knowledge that this treatment of steel has the effect of increasing its strength and toughness so enormously, has produced fruits in several directions. One of these, bearing on the present subject, is the attempt to draw steel tubes of any length, or section or substance. Throughout the engineering world there are many purposes (indeed, wherever motion is involved) for which a strong light material would be extensively applied, provided it could be obtained at a moderate cost. To accomplish this operation, a hole or slit, according to the section required, is first formed in a short thick mass of steel; two dies are employed, the one internally (which remains in use throughout the operation), the other externally (which has to be exchanged for a smaller one at every passage). Then enormous hydraulic pressure is brought to bear in pulling it through the vacant space between the internal and the external dies, thus leaving a portion of the steel behind, which forms a reservoir of steel for the increased length, by future elongating with that which could not pass through at the rate of motion of the apparatus, but to

follow suit as it has opportunity, and then, by annealing the mass of steel, and using smaller and smaller external dies in succession, the thick lump *becomes* gradually elongated into any length of any section, and, if necessary, with the high qualities of the music wire.

With the object of carrying out such a manufacture, a company was recently formed in London to produce steel tubular forms of any size or section. A variety of remarkable specimens were produced by them which made every engineer's mouth water, and although commercially it has not yet succeeded (simply because the arrangements of the world were not quite ripe for it), still that, judging by all past experience, does not affect the question any more than the receding wave affects the rising tide. The grand fact remains that it is a possibility, by sufficient pressure and patience, to cause solid steel to flow into any hollow form of section without breaking its continuity; it is a wonderful triumph of mind over matter which cannot be ignored, and which has yet to accomplish most important results in the future history of the mechanism of the working world of applied mechanics, and the advantages are so apparent and so numerous, that its ultimate success is only a question of time.

My chief object in making the foregoing remarks, is chiefly to show that the natural laws which govern materials and things are a great lesson to be taught to our young students, before they enter the workshops of applied mechanics, and to show that the varied operations of the practical worker are thus intimately blended with the profoundest philosophy, and that the fashioning of matter into the various forms required by our civilisation, is not the drudgery, to a thinking mind, which it is generally considered to be, but that we are fellow-workers in carrying out and taking advantage of the natural laws, as laid down for men by the Grand Designer of the Universe.

EDUCATION, SCIENCE, AND ART IN INDIA.

MR. GRANT DUFF, in an admirable statement of the finances of India, in the House of Commons on Tuesday last, spoke as follows:—

"The next item to which he would allude was education, science, and art—our civilising agencies, which, with its £780,000, showed very poorly beside our colossal military outgoings. The purely educational portion of this sum of £780,000 went, for the most part, to the maintenance of government schools and colleges, but some of it also for grants in aid, scholarships, payment of inspectors, government book depôts, &c. We had six classes of schools in India—1, village or vernacular schools; 2, district schools, where English was taught in the higher classes; 3, colleges, where the education was conducted in English; 4, two presidency colleges, each with a faculty of Arts and Law; 5, the engineering and medical colleges; 6, the normal schools. In all, we might have about 20,000 school establishments, with a continually improving network of official inspection. It was a matter for congratulation to those who had had of late years the disposal of Indian patronage, that when the University of Edinburgh was called upon to select a successor to a man so very eminent as the late Sir David Brewster, it sent to the other end of the world for the Director of Public Instruction at Bombay. So much for our teaching machinery. Our machinery for testing the success of our higher education consisted of three universities—one at Bombay, one at Madras, and one at Calcutta; all three modelled on the University of London, and doing their work extremely well. £780,000 would not be a large sum, if the whole of it were spent on education, but out of this inconsiderable amount came innumerable expenses, such as those of our great surveys, the trigonometrical, the topographical, the revenue, and others; so also did the expenses of observatories, museums, scientific

and literary institutions, botanical gardens, and other things too numerous to mention. In the Central Provinces, which were about as big as the British Isles, surveys and museums seemed to have cost, in the year of which he was speaking, the magnificent sum of £35. This was, however, the day of small things in all these matters, and he heartily hoped that this item of Indian expenditure would steadily increase, because money expended on education and civilisation would, to take the lowest view, soon pay us cent. per cent."

ANNUAL INTERNATIONAL EXHIBITIONS OF SELECTED WORKS.

Her Majesty's Commissioners for the Exhibition of 1851 announce that the first of a series of annual international exhibitions of selected works of fine and industrial art will be opened in London, at South Kensington, on Monday, the 1st of May, 1871, and be closed on Saturday, the 30th September, 1871.

The exhibitions will take place in permanent buildings, about to be erected adjoining the arcades of the Royal Horticultural Gardens.

The productions of all nations will be admitted, subject to obtaining the certificate of competent judges that they are of sufficient excellence to be worthy of exhibition.

The objects in the first exhibition will consist of the following classes, for each of which will be appointed a reporter and a separate committee:—

I. *Fine Arts*.—1. Painting of all kinds, in oil, water colours, enamel, porcelain, &c. 2. Sculpture in marble, wood, stone, terra-cotta, metal, ivory, and other materials. 3. Engravings, lithography, photography, &c. 4. Architectural designs and models. 5. Tapestries, embroideries, lace, &c., shown for their fine art and not as manufactures. 6. Designs for all kinds of decorative manufactures. 7. Copies of ancient pictures, enamels, reproductions in plaster, electrotypes of fine ancient works of art, &c.

II. *Scientific Inventions and New Discoveries of all kinds*.

III. *Manufactures*.—(a.) Pottery of all kinds, including that used in building, viz., earthenware, stoneware, porcelain, parian, &c., with machinery and processes for the preparation of such manufactures. (b.) Wool and worsted fabrics, with the raw produce and machinery for manufactures in the same. (c.) Educational.—1. School buildings, fittings, furniture, &c.; 2. Books, maps, globes, &c.; 3. Appliances for physical training, including toys and games; 4. Specimens and illustrations of modes of teaching fine art, natural history, and physical science.

IV. *Horticulture*.—International exhibitions of new and rare plants, and of fruits, vegetables, flowers and plants, showing specialities of cultivation, will be held by the Royal Horticultural Society, in conjunction with the above exhibitions.

In Classes II. and III. producers will be permitted to send one specimen of every kind of object they manufacture, such object being distinguished for novelty or excellence. Detailed rules applicable for each of the above classes, and lists of the separate trades engaged in the production of objects of manufacture, will be issued. Special rules for horticultural exhibitions will be issued by the Royal Horticultural Society.

The arrangement of the objects will be according to classes and not nationalities, as in former International Exhibitions.

One-third portion of the whole available space will be assigned absolutely to foreign exhibitors, who must obtain certificates for the admission of their objects from their respective governments. Foreign countries will appoint their own judges. The remaining two-thirds of the space will be filled by objects produced either in the United Kingdom, or, if produced abroad, sent direct to the building for inspection and approval of judges selected for the British exhibitors. Objects not accepted

for exhibition must be removed according to the notices given, but no objects exhibited can be removed until the close of the exhibition.

All exhibitors, or their agents, must deliver at the building, into the charge of the proper officers, the objects unpacked and ready for immediate exhibition, and free of all charges for carriage, &c.

Her Majesty's Commissioners will find large glass cases, stands, and fittings, free of cost to the exhibitors, and, except in the case of machinery, carry out the arrangement of the objects by their own officers.

Her Majesty's Commissioners will take the greatest possible care of all objects, but they will not hold themselves responsible for loss or damage of any kind.

Prices may be attached to the objects, and exhibitors will be encouraged to state their prices. Agents will be appointed to attend to the interests of exhibitors.

Every object must be accompanied with a descriptive label, stating the special reason, whether of excellence, novelty, or cheapness, &c., why it is offered for exhibition.

Due notice will be given of the days for receiving each class of objects; and, to enable the arrangements to be carried into effect, strict punctuality will be required from all exhibitors, both foreign and British. Objects delivered after the days appointed for their reception cannot be received.

Reports of each class of objects will be prepared immediately after the opening, and will be published before the 1st June, 1871.

Each foreign country will be free to accredit an official reporter for every class in which objects made in such country are exhibited, for the purpose of joining in the reports.

There will be no prizes, but a certificate of having obtained the distinction of admission to the exhibition will be given to each exhibitor.

A catalogue will be published in the English language, but every foreign country will be free to publish a catalogue in its own language if it think fit.

THE LONDON CAB SYSTEM.

The following is an abstract of the Bill for amending the law relating to hackney and stage carriages within the metropolitan police district, prepared and brought in by Mr. Bruce, Secretary of State for the Home Department, and Mr. Knatchbull-Hugessen:—

It proposes to enact that one of Her Majesty's Principal Secretaries of State may, from time to time, license to ply for hire, within the limits of this Act, such number of hackney and stage carriages of such description, and to be distinguished in such manner, as he may by order prescribe. Any license in respect of a hackney or stage carriage under this section may be granted at such price, on such conditions, be in such form, be subject to revision or suspension in such events, and generally be dealt with in such manner as the said Secretary of State may by order prescribe, subject as follows:—

That a hackney or stage carriage license shall, if not revoked or suspended, be in force for one year, and there shall be paid in respect thereof to the receiver of the metropolitan police, to be carried to the account of the metropolitan police fund, such sum, in the case of a hackney carriage not exceeding £2 2s., and in the case of a stage carriage not exceeding £3 3s., as the said Secretary of State may prescribe.

That in any such orders provision shall be made for the transfer of a hackney or stage carriage license to the widow or to any child of full age, of any person to whom a hackney or stage carriage license has been granted, who may die during the continuance of such license, leaving a widow or child of full age, and also for the transfer of a hackney or stage carriage license to the husband of any woman to whom such license has been granted and who marries during the continuance thereof.

Penalties are also to be imposed on the use of unlicensed carriages.

No hackney or stage carriage shall ply for hire unless under the charge of a driver having a license from the Secretary of State. If any hackney or stage carriage plies for hire in contravention of this section, the person driving the same, and also the owner of such carriage, unless he proves that the driver acted without his privity or consent, shall respectively be liable to a penalty not exceeding 40s.

A license to the driver of a hackney or stage carriage may be granted at such price, on such conditions, be in such form, be subject to revocation or suspension in such events, and generally be dealt with in such manner as the Secretary of State may by order prescribe, subject to this provision, that the license shall, if not revoked or suspended, be in force for one year, and there shall be paid in respect thereof to the receiver of the metropolitan police, to be carried to the account of the metropolitan police fund, such sum not exceeding 5s. as the Secretary of State may prescribe.

The Secretary of State may from time to time, by order, make regulations for regulating the number of persons to be carried in any hackney or stage carriage, and in what manner such number is to be shown on such carriage, and how such hackney carriages are to be furnished or fitted.

For fixing the stands of hackney carriages, and the distances to which they may be compelled to take passengers, and the persons to attend at such stands.

For fixing the rates or fares, as well for time as distance, to be paid for hackney carriages, and for securing the due publication of such fares; provided that it shall not be made compulsory on the driver of any hackney carriage to take passengers at a less fare than the fare payable at the time of the passing of this act.

For forming, in the case of hackney carriages, a table of distances, as evidence for the purpose of any fare to be charged by distance, by the preparation of a book, map, or plan, or any combination of a book, map, or plan.

For securing the safe custody and re-delivery of any property accidentally left in hackney or stage carriages, and fixing the charges to be paid in respect thereof, with power to cause such property to be sold or to be given to the finder, in the event of its not being claimed within a certain time.

In fixing the stands for hackney carriages within the City of London and the liberties thereof, the consent of the Court of the Lord Mayor and Aldermen shall be required to any stand appointed by the Secretary of State.

No hackney carriage shall be compelled to take any passenger beyond the limits of this Act, or a greater distance for any one drive than six miles.

During such portion of time between sunset and sunrise as is from time to time prescribed, no driver shall ply for hire unless the hackney carriage under his charge be provided with a lamp, properly trimmed and lighted, and fixed outside the carriage in such manner as is prescribed.

In this Bill "stage carriage" is defined to mean any carriage for the conveyance of passengers which plies for hire in any public street, road, or place within the limits of this act, and in which the passengers or any of them are charged to pay separate and distinct, or at the rate of separate and distinct, fares for their respective places or seats therein. "Hackney carriage" means any carriage for the conveyance of passengers which plies for hire within the limits of this Bill, and is not a stage carriage.

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

Par. Numb.
Delivered on 13th July, 1869.

- 197. Bill—Telegraphs.
- 202. " Public Works (Ireland).
- 292. Friendly Societies (Scotland)—Report.
- 299. Constabulary (Ireland)—Statement.

Delivered on 14th July, 1869.
181. Bill—Metropolitan Board of Works (Loans).

- 208. " Drainage and Improvement of Lands (Ireland) Act (1863) Amendment.
- 209. " Irish Church (as amended by the Lords).
- 210. " Inclosure Awards (County Palatine of Durham) (amended).
- 211. " Nitro-glycerine.
- 282. Municipal Boroughs (England and Wales)—Abstract.
- 305. Witnesses (House of Commons)—Report from the Select Committee.

Delivered on 15th July, 1869.

- 177. Bill—Corn and Grain Measurement.
- 207. " Roads and Bridges (Scotland).
- 212. " Contagious Diseases (Animals) (No. 2) (amended in Committee, and on Re-commitment).
- 213. " Poor Law (Ireland) Amendment (No. 2) (amended by Select Committee).
- 214. " Metropolitan Building Act (1855) Amendment.
- 280. Superior Courts of Common Law, &c.—Return.
- 294. Registration of Voters—Report.
- 307. New Zealand, Part I. (War)—Return.
- 310. Post Office Savings Banks—Return.
- 313. Clerk of A-size—Report.
- 320. Cattle and Sheep—Report of Dr. Simonds.
- Technical Instruction in Germany and Switzerland—Report.

Delivered on 16th July, 1869.

- 215. Bill—Parochial Schools (Scotland) (amended).
- 216. " Trades Unions (Protection of Funds).
- 217. " Public Schools Act (1868) Amendment.
- 27. Public Accounts—First and Second Reports.
- 317. New Courts of Justice—Correspondence.
- 322. Education (Scotland)—Minute.
- Miscellaneous Statistics of the United Kingdom, Part VII.

Delivered on 17th July, 1869.

- 201. Bill—Warehousing of Wines and Spirits, &c.
- 203. " Clerks of Assize.
- 206. " Cinque Ports Act Amendment.
- 290. Isle of Man—Account.
- 309. Brewers, &c.—Accounts.
- 314. Adulteration of Food and Drink (Metropolis)—Return.
- Public Petitions—Twenty-ninth Report.

Delivered on 19th July, 1869.

- 218. Bill—Courts of Justice Salaries and Funds (as amended on consideration).
- 87. (1.) Public Accounts—Appendix to Reports.
- 318. Militia Regiments (Foreign Service)—Return.

Delivered on 21st July, 1869.

- 219. Bill—Railways Abandonment (amended).
- 220. " Railway Construction Facilities Act (1864) Amendment (amended).
- 221. " Metropolitan Commons Act (1866) Amendment (as amended by the Select Committee).
- 222. " Seeds Adulteration (as amended by the Select Committee).
- 224. " Besses Lights (Ceylon).
- 311. Fortifications—Accounts.
- 325. Colonial Governors—Return.
- 330. Fortifications—Statement.
- 332. East India (Progress and Condition)—Statement.
- 333. Metropolitan Commons Act (1866) Amendment Bill—Special Report.
- 336. Office of Works—Papers.
- Public General Acts—Chap. 23 to 31.

Delivered on 22nd July, 1869.

- 223. Bill—Fortifications (Provision for Expenses).
- 337. (A.) Poor Rates and Pauperism—Return (A).
- 342. Pauperism (Metropolis)—Returns.

SESSION 1868.

- 433. (10) Endowed Charities (County of Leicester)—General Digest.

Delivered on 23rd July, 1869.

- 225. Bill—New Parishes and Church Building Acts Amendment.
- 226. " Contagious Diseases (Animals) (No. 2) (as amended on consideration of Bill as amended).
- 229. " Admiralty District Registries.
- 230. " Railway Construction Facilities Act (1864) Amendment (as amended in Committee, and on Re-commitment).
- 306. Contagious Diseases Act (1866)—Report.
- 321. Lunacy—Twenty-third Report of Commissioners.
- 324. Smoke Nuisance Abatement (Metropolis) Act, 1853—Return.
- 326. Education (Ireland) Annual Report.
- 327. Public Income and Expenditure (30th June, 1869)—Account.
- 329. Chamber of London—Annual Accounts.

Patents.

From Commissioners of Patents' Journal, July 30.

GRANTS OF PROVISIONAL PROTECTION.

- Agricultural implement for digging—1722—J. C. Norman.
- Agricultural implements—2141—J. H. Johnson.
- Æro-hydraulic engines—2126—V. Colne.
- Bale ties—2214—M. Tildesley.
- Bed-head bags, &c.—1972—R. Knowles and J. Lindley.
- Bicycles, &c.—2154—B. Russ.

Billiards, &c., apparatus for indicating the points made and registering the number of games played at—2136—J. J. Cousins.
 Blast furnaces—2149—J. W. Ormiston.
 Boilers for marine purposes—2072—W. Allan and P. D. Nichol.
 Boots and shoes, manufacturing and fastening the soles and heels of—2220—W. Currie.
 Boots, &c., machinery for manufacturing upper leathers for—2132—W. W. H. Smith.
 Brick buildings, waterproof facing for—2206—G. Follett.
 Buttons and studs—1764—C. E. de Lorière.
 Cables for the transmission of electric currents—2177—A. M. Clark.
 Camping trunks—1959—C. L. V. Yon.
 Canal boats, &c., propelling—2064—H. H. Murdoch.
 Canal boats, &c., propelling—2147—W. R. Lake.
 Cards for carding cotton, &c.—2086—J. Worth and W. Turner.
 Cast-iron rolls and shafts, &c., bearings for—2192—W. Rose.
 Circular saw benches—2146—J. Grint.
 Coiled springs, &c.—2138—C. D. Abel.
 Combs—2234—J. Hayward.
 Cotton, &c., spinning, &c.—2197—H. Higgins and T. S. Whitworth.
 Cucumber frames, &c., apparatus for opening and closing the lights of—2150—G. Yates and J. R. Williams.
 Disinfectants, supplying and distributing—2186—T. Holt.
 Driving belts—2188—F. Fleming.
 Dyeing and printing—2196—J. H. Johnson.
 Electro-magnetic engines—2160—H. E. Newton.
 Fecal and excremental matters, &c., disinfecting and deodorizing—815—J. Carter.
 Feeding bottles—1980—W. Coleman and S. Turton.
 Fire-arms, breech-loading—2169—H. E. Newton.
 Fire-arms, breech-loading—2164—A. Ancion.
 Fire-arms, breech-loading—2218—G. T. Abbey.
 Fire-arms, &c., breech-loading—2107—T. Restell.
 Flax, machinery for dressing and preparing—2131—G. Lowry.
 Flax, &c., apparatus for preparing—2005—A. V. Newton.
 Forge fires—1350—J. Conway.
 Gas meters—2163—D. N. Defries.
 Glass blowing—2182—J. B. Fondu.
 Hoods for invalid perambulator and other vehicles—2230—J. Walsh.
 Hops, obtaining extract from—2212—J. H. Johnson.
 Horse boots, elastic—2184—W. Williams.
 Horse rakes—2200—H. B. Clark.
 Hydrochloric acid—2139—J. T. Way.
 Knife-cleaning apparatus—2161—A. Simpson.
 Letter boxes, &c.—2228—W. Dennis.
 Liquids, apparatus for drawing—2151—F. G. Fleury.
 Liquids, apparatus for evaporating—2144—W. Hosack.
 Locomotives, &c.—2135—C. de Bergue.
 Looms—2130—J. and J. Leeming.
 Looms—2180—B. Hunt.
 Manumotive apparatus—2181—R. Duerre.
 Marline spikes—2204—W. R. Lake.
 Matchets and outlasses—2216—F. M. Mole.
 Metallic surfaces, removing artificial coatings from—2053—W. R. Lake.
 Mills for grinding and crushing corn, &c.—2183—T. Thomas.
 Mosaic, &c.—2156—W. Pidding.
 Nails, &c., machinery for making—2158—E. F. Jones.
 Oxygen, apparatus for charging atmospheric air with—2137—J. T. A. Mallet.
 Paper pulp, converting wood shavings, &c., into—2178—R. Schloesser and J. Irving.
 Photographic apparatus—2193—D. Trevor.
 Propelling apparatus, land or water—2194—A. Stansfeld.
 Railroad cars, &c., springs for—2208—A. H. Brandon.
 Railway carriages, buffing—2189—R. Saunders.
 Railway carriages, seats of—2127—J. Crowther.
 Railway crossings—2148—R. P. Williams.
 Railway trains, communication in—2125—J. Leetch.
 Roofs and floors, rafters for—2185—R. G. Fisher.
 Rope, &c.—2199—J. Ellison.
 Rope, &c.—2224—J. Green.
 Sewing machines—2170—J. H. Johnson.
 Sewing machines—2171—J. Imray and G. G. M. Hardingham.
 Ships—2145—W. Hosack.
 Ships—2202—J. Duke.
 Smelting, obtaining and utilising heat in the operation of—2142—J. Bernard.
 Smelting, &c.—2140—J. Bernard.
 Sofa-bedsteads—2089—W. R. Lake.
 Steam engines, mechanism for starting and working—2174—W. Macgeorge and A. Rigby, jun.
 Steam generators—2176—W. E. Gedge.
 Street-sweeping machines—1761—T. G. Greenstreet.
 Traction engines, &c., carrying the steering or other road wheels of—2162—M. Eyth.
 Transfer engraving—2175—R. Neale.
 Umbrella handles, &c.—2168—J. Bernstein.
 Velocipedes—2173—W. Leftwich.
 Velocipedes—2226—W. Bull.
 Velocipedes, &c.—2187—R. Olivier.
 Washing machines, &c.—2236—W. Laing.
 Water, apparatus for raising, forcing, and regulating the flow of—2152—R. B. Evered and R. Hurst.
 Window sashes, &c., axle pulleys for suspending—2167—C. J. Harcourt.
 Wire ropes, &c., securing the free ends of—2191—J. E. Holmes.
 Yarn or thread, machinery for winding—2210—J. Boyd.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

Boilers and furnaces—2232—R. Boyd.
 Looms, harness motion for power—2242—G. T. Bousfield.
 Shearing or clipping apparatus—2279—W. R. Lake.
 Water-measuring apparatus—2276—T. Parsons.

PATENTS SEALED.

324. V. Baker.	849. J. D. Morrison.
325. J. Slater.	1007. R. Allan.
331. F. Vauderaey.	1014. G. F. Griffin.
334. W. Maddick.	1077. W. A. Hunter.
335. R. R. Frohock.	1097. W. Ashton & J. H. Storey.
352. H. Jones.	1572. W. H. Dupré.
354. J. Jobson.	1575. C. W. Siemens.
360. J. Taylor.	1842. J. Brünner & H. Gutzkow.
368. H. A. Dufrené.	1860. J. Sturgeon.
425. W. R. Lake.	1686. T. R. Clarke, W. Bywater,
458. W. R. Lake.	T. Lawson, and C. L.
468. W. Smartt.	Lister.
483. J. Atkins.	1711. C. Ostlund.
561. B. W. Farey.	1715. J. Lloyd.
575. R. Morton.	1721. J. H. Johnson.
634. J. Farrington.	1797. W. R. Lake.

From Commissioners of Patents' Journal, August 3.

PATENTS SEALED.

356. W. Blundell.	730. W. R. Lake.
357. J. Page.	779. J. Thomas.
367. C. S. Dawson.	843. A. V. Newton.
369. J. S. Offord.	858. W. H. Phillips.
378. B. Walker and W. Tilson.	1015. D. J. Hoare.
388. B. Hunt.	1021. W. Johnson.
423. J. Carter.	1057. W. H. Douglas.
445. W. Summers.	1153. J. G. Jennings.
469. L. N. Legras.	1345. E. and T. Waltham.
500. T. H. Martin.	1468. T. G. F. Dolby.
514. S. Myers.	1583. R. Orley.
530. H. W. Whitehead.	1689. S. Thomas, jun.
573. B. Hunt.	1811. G. W. Howe.
697. J. A. Jaques, J. T. Oakley,	1847. B. Wartski.
and J. A. Fanshawe.	1856. A. Destouy.

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

2020. W. Smith.	2039. H. Holland.
1959. J. Adams.	2312. C. E. Brooman.
1960. W. Richards.	1963. J. McKenzie, T. Clunes,
1964. T. Greenwood & W. Keats.	and W. Holland.
1992. W. Furness and W. Bray.	1970. J. J. Bodmer.
1986. S. Chatwood and J. and T.	1994. J. T. H. Richardson.
Sturgeon.	2001. S. T. Armstrong.
2010. P. Murray.	1984. J. Farry and R. Morris.

PATENTS ON WHICH THE STAMP DUTY OF £100 HAS BEEN PAID.

2169. J. W. Woodford.	2193. G. Coles, J. A. Jaques, and
2175. A. V. Newton.	J. A. Fanshawe.
2181. G. A. Biddell.	

Registered Designs.

3930—June 9—An improved surface condenser—A. and R. Brown, Regent-road, Liverpool.
 3031—June 14—Improved cloak or skirt—H. Nicoll, Regent-street, London.
 3032—June 16—Combined despatch box and desk—John W. Allen, 37, Strand, London.
 3033—June 17—Parts of a tobacco pipe—Underhill and Jones, New-street, Birmingham.
 3034—July 1—Safe edge for cattle troughs and cisterns—Burney and Co., Millwall, London.
 3035—July 6—Steer's registered ear wire—Henry Steer, Market-head, Derby.
 3036—July 9—Manger and hay rack, with a self-cleaning water trough—H. R. Cottam, St. Pancras Ironworks, N.W.
 3037—July 16—A boot and shoe upper—W. Harber, 25, Moseley-road, Birmingham.
 3038—July 22—A new instrument for attaching papers and documents—Alex. Inglis, Highbury-hill-park, N.
 3039—July 22—A socket for knobs—Samuel Heath, Leopold street, Birmingham.
 3040—July 27—An apparatus for removing cigars from and replacing them in their boxes—John Jabez Stocken, 10, Gracechurch-street, London.
 3041—July 29—An improved gum bottle—S. Maw and Son, Aldersgate-street, London.
 3042—August 2—The registered type ribbon—Stephenson, Blake, and Co., Sheffield.